ANL/RERTR/TM-08-04

The REBUS-MCNP Linkage

Nuclear Engineering Division

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The REBUS-MCNP Linkage

by
J.G. Stevens
Nuclear Engineering Division, Argonne National Laboratory

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Abstract

The Reduced Enrichment Research and Test Reactor (RERTR) Program uses the REBUS-PC computer code to provide reactor physics and core design information such as neutron flux distributions in space, energy, and time, and to track isotopic changes in fuel and neutron absorbers with burnup. REBUS-PC models the complete fuel cycle including shuffling capability. REBUS-PC evolved using the neutronic capabilities of multi-group diffusion theory code DIF3D 9.0, but was extended to apply the continuous energy Monte Carlo code MCNP for one-group fluxes and cross-sections. The linkage between REBUS-PC and MCNP has recently been modernized and extended, as described in this manual. REBUS-PC now calls MCNP via a system call so that the user can apply any valid MCNP executable. The interface between REBUS-PC and MCNP requires minimal changes to an existing MCNP model, and little additional input. The REBUS-MCNP interface can also be used in conjunction with DIF3D neutronics to update an MCNP model with fuel compositions predicted using a DIF3D based depletion.

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The REBUS-MCNP Linkage

The REBUS-PC[1] (Reactor BUrnup System) depletion code has been extended to interface with the MCNP[2] neutron/photon transport code in two ways.

First, REBUS-PC can apply one group fluxes and cross sections calculated by a detailed MCNP model during depletion. This **two-way interface** moves number densities from REBUS to MCNP, and then moves fluxes and reaction rates from an MCNP tally file to REBUS. This mode allows detailed depletions without the need to develop a qualified diffusion approximation.

Second, REBUS-PC can be used with the standard DIF3D diffusion neutronics, but MCNP input decks can be updated with the REBUS number densities at each burnup step. This **one-way interface** allows rapid depletion with a qualified diffusion model, but with updated MCNP input decks to facilitate more detailed transport calculations (such as fluxes in complicated experimental devices).

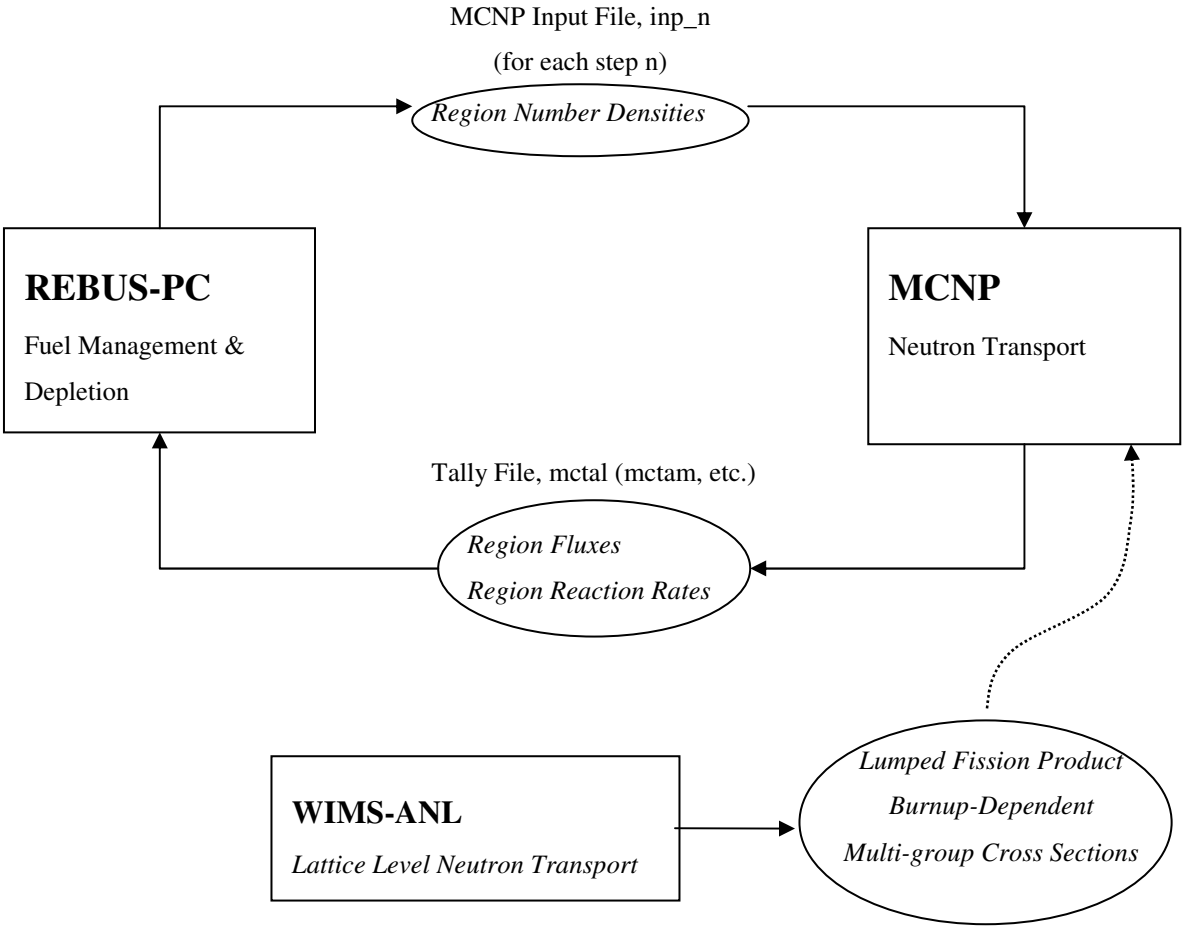
The two-way linkage was first created in 1998 by Hanan, Olsen, Pond, Woodruff, Bretscher, Matos and Leopondo.[3-6] The linkage was recently extended to:

- Call MCNP as a system call, so the user's reference MCNP is applied by REBUS
- Support a broad range of MCNP models (i.e., cell and material definitions)
- Provide depletion restart capability
- Support distinct depleting and/or non-depleting isotopes in each region
- Use Name-Mapped linkage to remove order dependence of MCNP and REBUS models
- Change power normalization to allow power changes at time-steps of a single run
- Allow rodded depletion per a predefined rod motion schedule (i.e., no criticality search)
- Provide extensive input checking/error reporting

An auxiliary code, buildreb has also been created to simplify creation of the abstract REBUS model for an existing MCNP model.

Depletion using MCNP fluxes and cross sections

Figure 1: Two-Way Interface where depletion applies MCNP fluxes and cross-sections

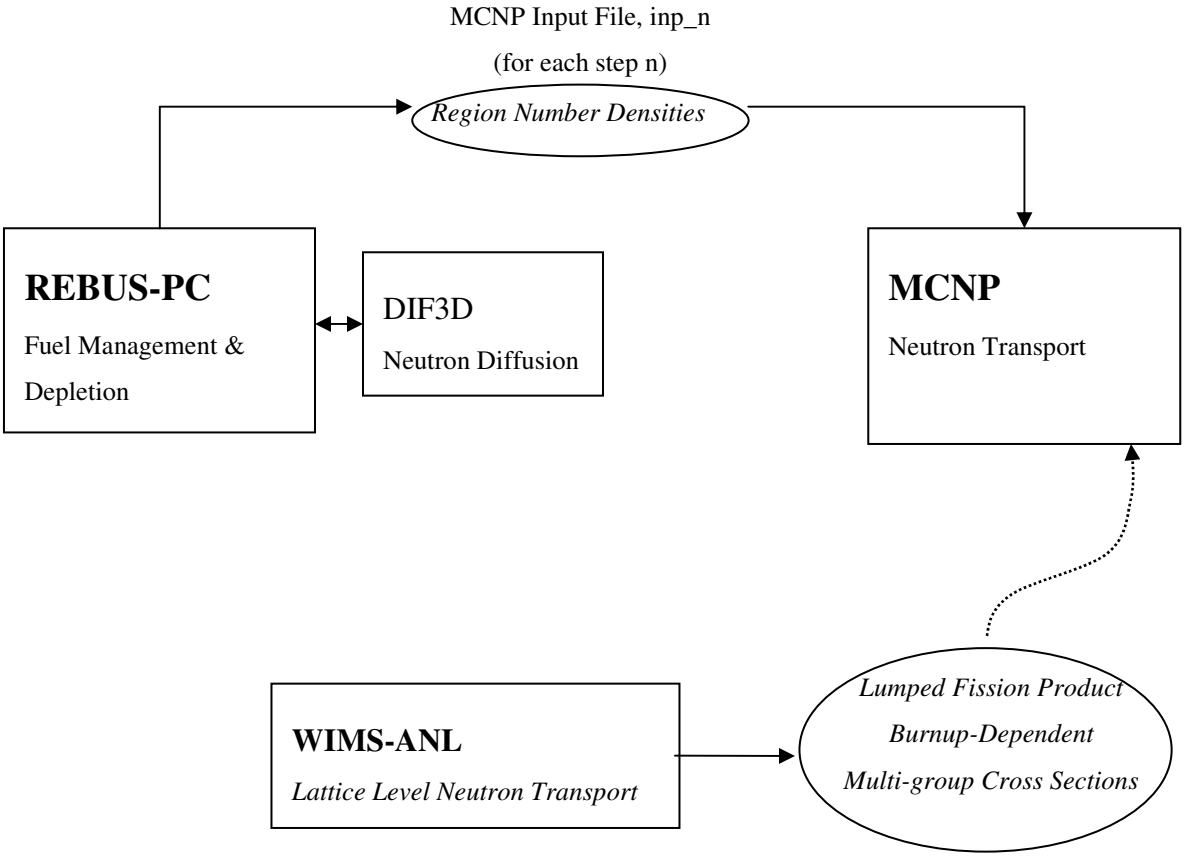


Note the indication of a lumped fission product. Continuous energy cross sections are not available for all fission products. Furthermore, the low number density and cross-section of most fission products would make the statistics of a tally for one group reaction rates infeasible.

The REBUS-MCNP approach applies a lumped fission product for isotopes of moderate significance, and a dump product for insignificant reaction products. In principle, the discrete-energy lumped fission product cross-section can be created by any means. WIMS-ANL[5-7] was modified to create a burnup-dependent 69 group cross-sections library for MCNP use for a lumped fission product.

Depletion using DIF3D fluxes and cross sections

Figure 2: One-Way Interface where depletion applies DIF3D fluxes and cross-sections, But MCNP Input Decks are created for each burnup step



Note the indication of a lumped fission product for the MCNP model. Continuous energy cross sections are not available for all fission products. Furthermore, the low number density and cross-section of most fission products would make the statistics of a tally for one group reaction rates infeasible.

The one-way interface will still apply one or more burnup dependent lumped fission product(s) to each composition updated, if A.REBMC card types 05 and 06 specify such an isotope or isotopes.

Input Files Required for the REBUS-MCNP Interface

Table 1: Two-Way Interface Files for Depletion using MCNP fluxes and cross sections

File Name (fixed in name, including case)	Purpose	Required?
rebusinp	REBUS Input for abstract model: only depleting regions and isotopes; each region must have appropriate volume, but the geometry has no other significance	**Required**
mcnpinpa	MCNP Input Template with actual geometry	**Required**
isoone	ISOTXS File used as structural template, must be 1 group, with each unique depleting isotope (and no other isotopes)	**Required**
a.rebmc	REBUS-MCNP Interface Directives	**Required**
tasks	PVM or MPI Directive for MCNP (i.e.,–*n*x1 for *n* cpus) (may be a part of the A.REBMC Card Type 13 directive)	Optional (but typical)
Path to xsdir	Path to MCNP xsdir file, which must point to discrete cross sections for any lumped fission product(s) applied in a.rebmc	**Required**
Path to srctp	Path to MCNP source file, though not strictly required, use of a source file is strongly encouraged to improve MCNP statistics during depletions (by reducing correlation of sampling)	Optional (but typical)
bol_mcnpinp	Specific mcnpinp input file for use at BOL point, if distinct. Evaluated by MCNP without update by REBUS, if present.	Optional (not typical)
mctal_1, mctal_2, etc.	MCNP Tally Files already calculated Used for depletion restarts – but must be used with care since	Optional

	there is no way for the code to verify that the files are correct	

Table 2: One-Way Interface Files for Depletion using DIF3D fluxes and cross sections

File Name (fixed in name, including case)	Purpose	Required?
Path to REBUS Input	REBUS Input: Model for DIF3D application, with all regions and isotopes in DIF3D geometry	**Required**
ISOTXS	ISOTXS File used for DIF3D neutronics, unless the REBUS input includes an ASCII dataset instead. Note that the ISOTXS file is not associated with the MCNP model in any way when DIF3D is used for REBUS neutronics.	**Optional (but typical)**
a.rebmc	REBUS-MCNP Interface Directives	**Required**
mcnpinpa	MCNP Input Template	**Required**

Input Requirements for Two-Way REBUS-MCNP Interface: MCNP fluxes & cross sections

Table 3: Two-Way Interface REBUS Requirements

Card	Issue for REBUS-MCNP Interface	Required?	Produced by buildreb?
A.STP027 Card 05	Specify that MCNP Interface will be used for fluxes and cross-sections rather than the DIF3D default	**Required**	No
A.NIP3 Card 06	REBUS Region Boundary Coordinates and Constant Mesh Structure The geometry is completely abstract in REBUS, but the volume of the region is critical for normalization. It is generally most convenient to apply constant size of 1.0 in the y and z dimensions, and to vary the x dimension by the area of the region in the xy plane (i.e., x dimension upper bound of region n set to lower bound + xy area of the region). **Region Label must have on-to-one correspondence to an MCNP depleting material** (note material, not cell since one material might be applied to many cells n the MCNP model)	**Required**	**Yes**
A.NIP3 Card 07	Area Specification to facilitate edits on planar, assembly, or core bases	**Optional (but typical)**	**Yes**
A.NIP3 Card 09	Variable Mesh Structure to define mesh boundaries consistent with A.NIP3 Card Type 06 above	**Required**	**Yes**
A.NIP3	REBUS Material Specification, Composition	**Required**	**Yes**

Cards 13-15	Specifications, and Assignment of Region to Composition to define unique isotope and number density of each depleting isotope for each region. **Note that isotope identifier must be unique for each region** (e.g., U235A0, U235A1, …) since the interface will write effective one-group MCNP cross sections of each region to a unique isotope on the ISOTXS file. Each active isotope must be assigned in each A.NIP3 Card 13 material. No invariant isotopes should exist in the abstract REBUS model. **One set of cards 13-15 must exist for each REBUS Region of A.NIP3 Card 06.**		
A.BURN Card 03	General Problem Definition	**Required**	No
A.BURN Card 10	Active Isotope Label Equivalence List to map the unique isotopes of each region to the generic local isotope (e.g., U235 as opposed to unique U235A0, U235A1, etc.). **The Card 09 local isotope labels must have a one-to-one correspondence to Active Isotopes in the interface (i.e., A.REBMC Card Type 05).**	**Required**	**Yes**
A.BURN Cards 11 or 35	Fuel Management Path Definition to assign materials to regions per A.NIP3 Card Types 14 and 15	**Required (either type 11 or 35)**	**Yes**

A.BURN Card 09	Burnup Chain Description, i.e. list of reactions tracked with associated yields. REBUS pre-defined chains may be applied, but require multiple lumped fission products rather than explicit products plus a single lump as is typical of REBUS-MCNP cases.	**Required (at least 1)**	No
A.BURN Card 24	Active Isotope Descriptions to define whether active isotopes are fissile	**Required (at least 1)**	No
A.BURN Card 25	Active Isotope Decay Constants (if an explicit A.BURN Card 09 burnup chain is defined rather than a pre-defined set)	**No**	No
A.BURN Card 36	General Fuel Management Parameters to define non-uniform burnup step sizes and /or relative powers. Note that A.BURN Cards 03, 35, and 36 all have entries that must be synchronized.	**Optional (but typical)**	No
A.DIF3D Card 06	Several DIF3D cards are required for memory management even though DIF3D will not be applied for neutronic solutions (a legacy of REBUS wrap around DIF3D). A.DIF3D Card 06 must define the Steady State Reactor Power (W) for power normalization.	**Required**	No
Other	Memory container sizing and edit control flags are typically set by A.STP027 Cards 01-02; A.DIF3D Cards 01-05; A.HMG4C Card 01; and A.BURN Cards 01 and 02	**Required Memory Allocations**	No

Table 4: Two-Way Interface MCNP Input Requirements

Card	Issue for REBUS-MCNP Interface	Required?	Updated by buildreb?
Cell	Composition Cross-Reference to map MCNP materials to REBUS regions and to Card Type 02 Interface Material Only the first line of a cell definition will be checked for a material number, whether in a full definitions (which has the material number as the first entry after the cell number) or a "like but" definition which has "mat=id" if the material differs from the original cell definition. Similarly, only the first line of a cell definition will be checked for a material density, whether in a full definitions (which has the material density as the second entry after the cell number) or a "like but" definition which has "rho=val" if the material density differs from the original cell definition.	**Required**	**Yes, Material & Density if shuffled**
Invariant Material	Invariant material definitions must appear before the REBREP flag comment in the mcnpinpa template. Data cards which follow the REBREP comment flag will not be copied from template to active input deck.		
Active Isotope "Pure	Each active isotope must be defined as a unique material to allow the FMn multipliers to be specified in the one group reaction rate tally.	**Required**	**No**

Materials”	For instance: m201 92235.60c 1.0 defines the U235 library entry as material 201 Entry (1 -6 201) on the tally FM card would collect the U235 total fission cross section in each geometric region of the tally.		
DRXS	**Discrete Cross Section list for Lumped Fission Product** Each ZAID of the lumped fission product, if applied, must be listed on the DRXS card.	**Not Required, but Typical**	**No**
One Group Flux Tally	A single tally must collect the **one-group neutron flux** for each depleting composition. En 20.0 will specify a one group tally. (E0 will set all tallies to one group) If a depleting composition is applied to more than one cell (e.g., the fuel meat in each plate of an assembly), then parentheses must be used in the tally specification to collect a single flux value for the composition. The tally cannot be segmented (i.e., no FSn card) since any variation that would warrant an FSn card implies the need for a distinct depleting material.	**Required**	**No**

	The tally does not need to be normalized in MCNP, since power level is set in REBUS and volume normalization can be applied in A.REBMC Card Type 01 specification. Thus, SDn 1.0 mr (for m+1 depleting compositions) can be applied in tally specification. The order of the tally regions is not significant for the interface. Name matching is used to infer the order of A.REBMC Card 01 compositions.		
One Group Reaction Rate Tally	A single tally must collect the **one-group neutron reaction rates** for each reaction of interest of each active isotope depleting composition. Microscopic cross-sections are calculated by dividing reaction rate tally by associated one group flux tally. En 20.0 will specify a one group tally. (E0 will set all tallies to one group) If a depleting composition is applied to more than one cell (e.g., the fuel meat in each plate of an assembly), then parentheses must be used in the tally specification to collect a single flux value for the composition. The tally cannot be segmented (i.e., no FSn card) since any variation that would warrant an FSn card implies the need for a distinct depleting material.	**Required**	**No**

	The tally does not need to be normalized in MCNP, since power level is set in REBUS and volume normalization can be applied in A.REBMC Card Type 01 specification. Thus, SDn 1.0 mr (for m+1 depleting compositions) can be applied in tally specification. **SDn for the reaction rate and flux tallies must match for associated regions.** The order of the tally regions is not significant for the interface, unless SDn other than 1 is applied. Name matching is used to infer the order of A.REBMC Card 01 compositions. The order of tally multipliers (FMn card) is not significant. Different reactions may be tracked for different isotopes. If a multiplier exists for a reaction that does not have data in the MCNP library, then zero cross sections will be transferred to REBUS for that reaction (of the specific isotope). If the tally does not include a multiplier for a reaction tracked in the REBUS model, then a warning will be edited, and zero cross sections will be transferred to REBUS for that reaction (of the specific isotope).		
Depleting Material	Any depleting materials in the mcnpinpa template file must appear after the REBREP flag. Those definitions will be ignored by REBUS-MCNP since the depleting material definitions are written from the REBUS model.	**Required**	**Yes**

	Each depleting material must have an id that matches an A.REBMC Card Type 01.		

Note that A.REBMC Card Types 09, 10, and 11 allow cell, surface, and/or data cards other than depleting materials to be altered during a REBUS-MCNP run by writing (verbatim), MCNP input that follows a REBREP flag comment in the Cell, Surface, or Data portions of the mcnpinpa MCNP input template.

The REBREP flag comment referred to is simply a comment line that begins with character c or C in column 1, and has keyword REBREP as the first word of the comment (where blanks are not meaningful).

A REBREP flag comment is required in the Data portion of the mcnpinpa template file since depleting materials are written after the flag comment. But the flag comments are only necessary in the Cell and Surface portions of the template if A.REBMC Card Types 09 or 10 specify cards to follow the comment.

MCNP Input restrictions:

MCNP allows a continuation lines to begin in column 1 if the preceding line ends with the & character, but this will often break the REBUS-MCNP interface since the first five columns are checked for cell or material id. Thus, continuation lines should always begin in column 6.

Table 5: Two-Way Interface Directive Requirements (A.REBMC)

Card	Issue for REBUS-MCNP Interface	Required?
01	Composition Cross-Reference to map MCNP materials to REBUS regions and to Card Type 02 Interface Material. Note that the Card Type 01 volume fractions are not used in the two-way	**Required**

	interface since the scheme requires one-to-one correspondence between MCNP depleting zones and REBUS depleting regions, with volume fraction of 1.0.	
02	Interface Material Definition to map a material to the lists of Active and Invariant Isotopes	**Required**
03	Active Isotope List, i.e., the list of MCNP ZAIDs of depleting isotopes	**Required**
04	Invariant Isotope List, i.e., the list of MCNP ZAIDs of isotopes that do not deplete (i.e., fuel matrix material) and associated invariant number densities (invariant isotopes do not exist in the abstract REBUS model)	**Required**
05	Isotope Name Cross Reference to map active MCNP ZAIDs to REBUS Local Isotope Labels (per A.BURN Card Type 10)	**Required**
06	Density Dependent Isotope Assignment Vector used to specify the appropriate specific MCNP ZAID of the burnup dependent lumped fission product vs. density of the ZAID that indicates burnup for the lumped fission product cross-section table	**Optional (but typical)**
07	Key Tally Identification to specify the MCNP tally numbers for flux and reaction rate tallies	**Required**
08	Power Conversion Constants to scale the MCNP tallies	**Required**
13	Command line (i.e., non-interactive) command by which REBUS should invoke MCNP	**Required**

Input Requirements for One-Way REBUS-MCNP Interface: DIF3D fluxes & cross sections

Table 6: One-Way Interface MCNP Input Requirements

Card	Issue for REBUS-MCNP Interface	Required?
Cell	Composition Cross-Reference to map MCNP materials to REBUS regions and to Card Type 02 Interface Material Only the first line of a cell definition will be checked for a material number, whether in a full definitions (which has the material number as the first entry after the cell number) or a "like but" definition which has "mat=id" if the material differs from the original cell definition. Similarly, only the first line of a cell definition will be checked for a material density, whether in a full definitions (which has the material density as the second entry after the cell number) or a "like but" definition which has "rho=val" if the material density differs from the original cell definition.	**Required**
Invariant Material	Invariant material definitions must appear before the REBREP flag comment in the mcnpinpa template. Data cards which follow the REBREP comment flag will not be copied from template to active input deck.	
Depleting Material	Any depleting materials in the mcnpinpa template file must appear after the REBREP flag. Those definitions will be ignored by REBUS-MCNP since the depleting material definitions are written from the REBUS model. Each depleting material must have an id that matches an A.REBMC Card Type 01.	**Required**

Note that A.REBMC Card Types 09, 10, and 11 allow cell, surface, and/or data cards other than depleting materials to be altered during a REBUS-MCNP run by writing (verbatim), MCNP input that follows a REBREP flag comment in the Cell, Surface, or Data portions of the mcnpinpa MCNP input template.

The REBREP flag comment referred to is simply a comment lien that begins with character c or C in column 1, and has keyword REBREP as the first word of the comment (where blanks are not meaningful).

A REBREP flag comment is required in the Data portion of the mcnpinpa template file since depleting materials are written after the flag comment. But the flag comments are only necessary in the Cell and Surface portions of the template if A.REBMC Card Types 09 or 10 specify cards to follow the comment.

There is no mechanism to write control rod positions searched upon by REBUS to the MCNP decks automatically. Only fuel number densities will be transferred from the REBUS DIF3D model to the MCNP input files.

MCNP Input restrictions:

MCNP allows a continuation lines to begin in column 1 if the preceding line ends with the & character, but this will often break the REBUS-MCNP interface since the first five columns are checked for cell or material id. Thus, continuation lines should always begin in column 6.

Table 7: One-Way Interface Directive Requirements (A.REBMC)

Card	Issue for REBUS-MCNP Interface	Required?
01	Composition Cross-Reference to map REBUS regions to MCNP materials, Card Type 02 Interface Material, and fuel meat volume fraction of REBUS region.	**Required**

	Note that the Card Type 01 volume fractions required in the one-way interface since the REBUS DIF3D depleting regions will mix non-depleting material with the depleting material.	
02	Interface Material Definition to map a material to the lists of Active and Invariant Isotopes	**Required**
03	Active Isotope List, i.e., the list of MCNP ZAIDs of depleting isotopes	**Required**
04	Invariant Isotope List, i.e., the list of MCNP ZAIDs of isotopes that do not deplete (i.e., fuel matrix material) and associated invariant number densities (invariant isotopes are not transferred from the homogenized REBUS model)	**Required**
05	Isotope Name Cross Reference to map active MCNP ZAIDs to REBUS Local Isotope Labels (per A.BURN Card Type 10)	**Required**
06	Density Dependent Isotope Assignment Vector used to specify the appropriate specific MCNP ZAID of the burnup dependent lumped fission product vs. density of the ZAID that indicates burnup for the lumped fission product cross-section table	**Optional (but typical)**

A.REBMC Card Type 12 allows the user to specify particular time steps at which MCNP Input File edits are desired. The default (i.e., no A.REBMC Cards of Type 12 in input) is for a file to be edited at each time step, but the user can avoid clutter by specifying only steps of interest.

A.REBMC Card 01: Composition Cross-Reference

Read as:

```
01 MCNPCMP REBREG [INTFMAT] [VOL] [VFRAC]
```

Read as free format tokens to avoid the need for quotes.

Where:

MCNPCMP: Integer Composition number in the MCNP input deck
Entry is required; there is no default or overlay.

REBREG: Character Region Name used in the REBUS Input
(A.NIP3 Card Type 06 Region Label)
Entry is required; there is no default or overlay.
1-6 characters may be used. No blanks are allowed in the name.

INTFMAT: Character Interface Material Name to be applied
(A.REBMC Card Type 02 Material Name)
Default can be set for run via MCNPCMP REBREG pair 0 DEFAUL
1-6 characters may be used, if a name is provided.
No blanks are allowed if a name is provided.

VOL: Volume (cc) of the material, or 1.0 if volume applied in MCNP tally
Used to normalize the MCNP tally read.
Default can be set for run via MCNPCMP REBREG pair 0 DEFAUL
The most transparent approach is to set SD=1.0 in MCNP, then apply VOL value(s) in the interface.
But, SD card with real volumes could be used in MCNP tally, if preferred.
VOL is used for MCNP->REBUS, but not for REBUS-DIF3D->MCNP

VFRAC: Volume fraction of the fuel meat within the homogenized REBUS-DIF3D region
Used to scale the number densities of the homogenized region for application in the detailed MCNP model.

Default can be set for run via MCNPCMP REBREG pair 0 DEFAUL

VFRAC is used for REBUS-DIF3D->MCNP, but not for MCNP->REBUS.

Reserved MCNPCMP REBREG pair 0 DEFAUL can be used to set the default value for INTFMAT, VOL, and VFRAC within a run.

Data Entry Requirements:

Order Dependence: None

For two-way interface which depletes with MCNP fluxes and cross-sections:
The mapping of MCNPCMP and REBREG must be one-to-one, i.e., exactly one card must exist for each depleting MCNP composition, and exactly one card must reference each depleting REBUS Region.

For one-way interface which depletes with DIF3D fluxes and cross-sections:
The mapping of MCNPCMP and REBREG must be one-to-many, i.e., exactly one card must exist for each depleting MCNP composition, but multiple cards may reference the same depleting REBUS Region.

If a card with MCNPCMP REBREG pair 0 DEFAUL is supplied, then INTFMAT, VOL, and/or VFRAC are only needed on if the default should be overridden.

For instance, the following two sets of entry have identical meaning:
(example is for two-way interface where depletion is based on MCNP fluxes and cross-sections)

1) No default value supplied:

```
01 1001 N1001 ACTVFU 67.243   $ Zone 1 of N1
01 2001 N2001 ACTVFU 67.243   $ Zone 2 of N1
01 3001 N3001 ACTVFU 67.243   $ Zone 3 of N1
01 1123 N1123 ACTVFU 18.679   $ Zone 1,1 of C3
01 2123 N2123 ACTVFU 18.679   $ Zone 2,1 of C3
01 3123 N3123 ACTVFU 18.679   $ Zone 3,1 of C3
01 1050 BP001 BP     11.207   $ Burnable Absorber Plate
```

2) Equivalent input set with default value supplied:

```
01    0 DEFAUL ACTVFU 67.243   $ Default Fuel Zone
01 1001 N1001                  $ Zone 1 of N1
01 2001 N2001                  $ Zone 2 of N1
01 3001 N3001                  $ Zone 3 of N1
01 1123 N1123,,       18.679   $ Zone 1,1 of C3
01 2123 N2123,,       18.679   $ Zone 2,1 of C3
01 3123 N3123,,       18.679   $ Zone 3,1 of C3
01 1050 BP001  BP     11.207   $ Burnable Absorber Plate
```

Note the commas to skip INTFMAT entries for MCNPCMPs 1123, 2123, and 3123. The commas are required if INTFMAT will be skipped but VOL will be entered. As indicated on the cards for MCNPCMPs 1001, 2001, and 3001, no commas are needed if neither INTFMAT nor VOL is entered on the card.

Similarly, the following two sets of entry have identical meaning:

(example is for one-way interface where depletion is based on DIF3D fluxes and cross-sections)

1) No default value supplied:

```
01 1001 RING1 ACTVFU,, 0.098  $ Pin 1 in Ring 1 of RZ Diffusion
01 2101 RING2 ACTVFU,, 0.156  $ Pin 2 in Ring 2 of RZ Diffusion
01 2201 RING2 ACTVFU,, 0.156  $ Pin 3 in Ring 2 of RZ Diffusion
01 2301 RING2 ACTVFU,, 0.156  $ Pin 4 in Ring 2 of RZ Diffusion
01 2401 RING2 ACTVFU,, 0.156  $ Pin 5 in Ring 2 of RZ Diffusion
01 2501 RING2 ACTVFU,, 0.156  $ Pin 6 in Ring 2 of RZ Diffusion
01 2601 RING2 ACTVFU,, 0.156  $ Pin 7 in Ring 2 of RZ Diffusion
01 1050 BP001 BP    ,, 0.005  $ Burnable Absorber Pin
```

2) Equivalent input set with default value supplied:

```
01    0 DEFAUL ACTVFU,, 0.156 $ Default Fuel Zone
01 1001 RING1,,,        0.098 $ Pin 1 in Ring 1 of RZ Diffusion
01 2101 RING2                 $ Pin 2 in Ring 2 of RZ Diffusion
01 2201 RING2                 $ Pin 3 in Ring 2 of RZ Diffusion
01 2301 RING2                 $ Pin 4 in Ring 2 of RZ Diffusion
01 2401 RING2                 $ Pin 5 in Ring 2 of RZ Diffusion
01 2501 RING2                 $ Pin 6 in Ring 2 of RZ Diffusion
01 2601 RING2                 $ Pin 6 in Ring 2 of RZ Diffusion
01 1050 BP001  BP,,     0.005 $ Burnable Absorber Pin
```

Note the commas to skip INTFMAT entries for MCNPCMPs 1001 and 1050. The commas are required if INTFMAT and VOL will be skipped but VFRAC will be entered. As indicated on the cards for MCNPCMPs 2101, 2201, 2301, 2401, 2501, and 2601, no commas are needed if neither INTFMAT, VOL, nor VFRAC is entered on the card.

A.REBMC Card 02: Interface Material Definition

Read as:

```
02 INTFMAT ACTVLST [INVLST]
```

Read as free format tokens to avoid the need for quotes.

Where:

INTFMAT: Character Interface Material Name applied
(applied in A.REBMC Card Type 01)
Entry is required; there is no default or overlay.
1-6 characters may be used. No blanks are allowed in the name.

ACTVLST: Character Active Isotope List to be applied
(A.REBMC Card Type 03)
Default can be set for run via card with INTFMAT value DEFAUL
1-6 characters may be used, if a name is provided.
No blanks are allowed if a name is provided.

INVLST: Character Invariant Isotope List to be applied
(A.REBMC Card Type 04)
Entry may be blank or skipped if the region has no invariant isotopes.
Default can be set for run via card with INTFMAT value DEFAUL
1-6 characters may be used, if a name is provided.
No blanks are allowed if a name is provided.

Reserved INTFMAT DEFAUL can be used to set the default value for both ACTVLST and INVLST within a run.

For example:

```
02 UMo FUEISO MoMtrx
02 UO2 FUEISO Oxide
```

Would apply the same active isotope lists to two fuel types, but would apply distinct invariant isotopes (for two distinct matrix materials).

```
02 DEFAUL FUEISO
02 UMo,, MoMtrx
02 UO2,, Oxide
```

Would apply the same active isotope list, FUEISO, to two fuel types, but would apply distinct invariant isotopes (for two distinct matrix materials).

Note the commas to skip ACTVLST entries for INTFMAT UMo and UO2. The commas are required if ACTVLST will be skipped but INVLST will be entered. No commas are needed if neither ACTVLST nor INVLST is entered on the card.

```
02 N1AsBl FUEISO N1AsBl
02 N2AsBl FUEISO N2AsBl
```

Would apply the same active isotope lists to two fuel assemblies, but would apply distinct invariant isotopes (for two distinct matrix number densities).

A.REBMC Card 03: Active Isotope List

Read as:

```
03 ACTVLST MCISO(1)  [MCISO(2) … MCISO(6)]
```

Read as free format tokens to avoid the need for quotes.

Where:

ACTVLST: Character Active Isotope List name
(applied in A.REBMC Card Type 02)
Entry is required; there is no default or overlay.
1-6 characters may be used. No blanks are allowed in the name.

MCISO(i): Character MCNP Isotope Identifier, ZAID, of a depleting isotope
(Cross Referenced to REBUS Name on A.REBMC Card Type 05)
For example, 92235.66c
Entry is required for any isotope of interest, there is no default or overlay.
Up to 10 characters may be used. No blanks are allowed in the name.

The number of MCISO entries on each Card Type 03 can be between 1 and 6.
The complete list for each ACTVLST name is constructed from all Card Type 03 with the same ACTVLST.

For example:

```
03 FUEISO  92235.66c  92238.66c
03 FUEISO  92234.66c  92236.66c
```

Is equivalent to:

```
03 FUEISO  92235.66c  92238.66c  92234.66c  92236.66c
```

Note that the MCNP composition cards will be edited with isotopes in the order entered on associated card type 03.

A.REBMC Card 04: Invariant Isotope List

Read as:

```
04 INVVLST MCISO(1) RNUMDN(1) [MCISO(2) RNUMDN(2) … MCISO(3) RNUMDN(3)]
```

Read as free format tokens to avoid the need for quotes.

Where:

INVVLST: Character Invariant Isotope List name
(applied in A.REBMC Card Type 02)
Entry is required, there is no default or overlay.

MCISO(i): Character MCNP Isotope Identifier, ZAID, of a depleting isotope
(Not Cross Referenced to REBUS Name since invariant isotopes are not treated by REBUS for Monte Carlo Depletion)
For example, 13027.60c
Entry is required for any isotope of interest, there is no default or overlay.
Up to 10 characters may be used. No blanks are allowed in the name.

RNUMDN (i): Atom density of depleting isotope MCISO(i), in atoms/b-cm
For example, 5.34E-02
Entry is required for any isotope of interest, there is no default or overlay.

The number of MCISO, RNUMDN pairs on each Card Type 04 can be between 1 and 3.
The complete list for each INVVLST name is constructed from all Card Type 04 with the same INVLST.

For example:

```
04 U3Si2A 13027.60c 3.06388e-2
04 U3Si2A 14000.60c 8.32642e-3
```

Is equivalent to:

```
04 U3Si2A 13027.60c 3.06388e-2 14000.60c 8.32642e-3
```

Note that the MCNP composition cards will be edited with isotopes in the order entered on associated card type 04.

A.REBMC Card 05: Isotope Name Cross-Reference

Read as:

```
05 MCISO REBISO [DDIAFM] [MCISBU]
```

Read as free format tokens to avoid the need for quotes.

Where:

MCISO: Character MCNP Isotope Identifier, ZAID, of a depleting isotope
For example, 92235.66c
Entry is required for any isotope of interest, there is no default or overlay.
Up to 10 characters may be used. No blanks are allowed in the name.

REBISO: Character REBUS Local Isotope Label associated with MCISO
(A.BURN Card Type 10 Local Isotope Label)
For example, U235
Entry is required for any isotope of interest, there is no default or overlay.
1-6 characters may be used. No blanks are allowed in the name.

DDIAFM: Character Density Dependent Isotope Assignment Format
i.e., the format of the MCISO identifier for a lumped fission product or other identifier that is assigned to MCNP compositions as a function of atom density (per A.REBMC Card Type 06)

Default is blank, that is no density dependent isotope assignment.
Entry is required for any A.REBMC Card Type 06 DDIAFM.
2-6 characters may be used. No blanks are allowed in the name.

The variable portion of the ZZZAAA name must be replaced with # characters that will be replaced by the integer of the closest matching A.REBMC Card Type 06 atom density step.

If the step number has fewer digits than the number of # characters in DDIAFM, then the number will be padded with leading 0s, e.g.,
9999## would be the prefix for 999901.69d, 999902.69d, etc.

If the step number has more digits that the number of # characters in DDIAFM, then it is edited directly if the total length of the resultant ZZZAAA remains 6 or fewer characters, e.g.,
888# would be the prefix for 8881.69d, 8882.69d, …, 88810.69d, etc.

MCISBU: Character MCNP Isotope Identifier, ZAID, of the isotope whose atom density determines which DDIAFM step index to apply in the MCNP run
For example, 92235.66c

Default is 92235.xxx (i.e., all Cards of Type 05 searched for the 92235 entry, and the atom density of that MCISO is then used to select a step from the associated Card Type 06 list of densities.

If an entry is given, then DDIAFM must be present on the card, and the MCISOBU entry must match one of the other Card Type 05 MCISO.

Examples:

```
05  92235.66c  U235
05  94239.66c  Pu239
05 999901.69d  LumpFP  9999##
05   8881.69d  PuLFP  888#    94239.66c
```

The set of cards above would lead to selection of the ## index of LumpFP 9999##.69d that had the closest match to the 92235.66c atom density listed on the Card Type 06 list for 9999##. (i.e. default MCISBU used by finding 92235.66c among cards of type 05).

The set of cards above would lead to selection of the # index of PuLFP 888#.69d that had the closest match to the 94239.66c atom density listed on the Card Type 06 list for 888#.

A.REBMC Card 06: Density Dependent Isotope Assignment

Lumped fission product cross sections or detector response functions at discrete energies (i.e., a 69 group library as opposed to MCNP continuous energy cross sections) in the MCNP model must be altered during burnup to apply the appropriate set of discrete energy cross sections. REBUS-MCNP facilitates this process by allowing the user to specify a DDIAFM format to write the particular MCNP isotope name (with some integer index in the name) for the density entry that best matches the current density of the particular MCNP material. The 92235 density is used as the comparison value by default, but any other depleting isotope could be used (for a Rhodium detector, for instance).

The capability exists to modify cross section assignment vs. depletion, but the name Density Dependent Isotope Assignment reflects the fact that actual current density is compared (rather than burnup), and the ZAID Isotope Identifier is altered rather than an explicit cross section.

The user must assure that the cross sections or response functions exist as MCNP data libraries with the associated ZAID names.

Card Type 06 is Read as:

```
06 DDIAFM DDIADN(i) DDIAEX(i)
```

Read as free format tokens to avoid the need for quotes.

Where:

DDIAFM: Character Density Dependent Isotope Assignment Format
(used on A.REBMC Card Type 06)
Entry is required for any isotope of interest, there is no default or overlay.
2-6 characters may be used. No blanks are allowed in the name.

DDIADN(i): Density Dependent Isotope Assignment Atom Density (atoms/b-cm) associated with index position i in list of all DDIADN entries for the DDIAFM
Entry is required for any step of interest, there is no default or overlay.

DDIAEX(i): Character Density Dependent Isotope Assignment Explicit Name associated with index position i in list of all DDIADN entries for the DDIAFM
The explicit name must follow the numeric substitution pattern of the associated DDIAFM (i.e., DDIAEX of 999902 is consistent with DDIAFM 9999##).
Entry is required for any step of interest, there is no default or overlay.

The complete list for each DDIAFM name is constructed from all Card Type 06 with the same DDIAFM.

Examples:

The user may choose to skip some points of the lumped fission product that were stored in the associated MCNP library in order to reduce the number of one-group cross-sections evaluated by MCNP tallies.

For instance, the sample set:

```
06 9999## 2.42889E-03  999901
06 9999## 2.42804E-03  999902
06 9999## 2.42634E-03  999903
06 9999## 2.42123E-03  999904
06 9999## 2.41613E-03  999905
06 9999## 2.41103E-03  999906
06 9999## 2.40593E-03  999907
06 9999## 2.40084E-03  999908
06 9999## 2.39575E-03  999909
06 9999## 2.39067E-03  999910
```

could be simplified if there is no fresh or nearly fresh fuel in the reactor. The card set below shows that 999901-999903 have been:

```
06 9999## 2.42123E-03  999904
06 9999## 2.41613E-03  999905
06 9999## 2.41103E-03  999906
06 9999## 2.40593E-03  999907
06 9999## 2.40084E-03  999908
06 9999## 2.39575E-03  999909
06 9999## 2.39067E-03  999910
```

Examples of applications:

For the list of 10 DDIADN entries on the card type 06 examples above, and

```
05  92235.66c  U235
05 999901.69d  LumpFP  9999##
```

1) A zone with 92235.66c atom density 2.43E-3 atoms/b-cm would result in 999901.69d for the complete card set, or 999904.69d for the reduced card set
(i.e., value larger than first entry gets index 1, with warning)

2) A zone with 92235.66c atom density 2.42E-3 atoms/b-cm would result in 999904.69d
(because index 4 entry is closer to 2.42E-3 than index 5)

3) A zone with 92235.66c atom density 2.30E-3 atoms/b-cm would result in 999910.69d
(i.e., value smaller than last entry gets index of last entry, with warning)

Data Entry Requirements:

The list of all DDIADN densities on all A.REBMC Card Type 06 for a particular DDIAFM must be monotonically decreasing. The selection of closest fit will be output as an integer between 1 and the number of entries for the particular DDIAFM.

The associated DDIAEX entries must be unique, but do not need to be in order or contiguous.

If the actual density in the zone is higher than the first entry or lower than the last entry, then a warning message will be edited to the REBUS-MCNP output.

Note:

The isotope index is not interpolated – and thus nether are the cross sections applied in MCNP. The capability allows a closest match, not an interpolation.

A.REBMC Card 07: Key Tally Identification

Read as:

```
07 NTALFLX NTAL1XS
```

All integers, read with free format.

Where:

NTALFLX: MCNP tally number for the one group flux in each depleting region. Entry is required, there is no default or overlay.

NTAL1XS: MCNP tally number for the one group microscopic cross sections. Entry is required, there is no default or overlay.

Data Entry Requirements:

One and only one card type 07 must be read.

Example:

```
07  4  14
```

A.REBMC Card 08: Power Conversion Constants

Read as:

```
08 NUBAR KAPPA KUNIT INCLCAP
```

Read with free format.

Where:

NUBAR: Average number of neutrons produced per fission in MCNP model.
Entry is required, there is no default or overlay.

KAPPA: Average energy per fission in MCNP model, in units per KUNIT below.
Entry is required, there is no default or overlay.

KUNIT: Unit flag for KAPPA value above:
0 for MeV/fission
1 for J/fission
Entry is required, there is no default or overlay.

INCLCAP: Flag for whether to include capture energy in REBUS model
0 to ignore capture energy in REBUS
1 to include capture energy in REBUS
Entry is required, there is no default or overlay.

Data Entry Requirements:

One and only one card type 08 must be read.

Example:

```
  08  2.43771  1.93722E+02  0  0
```

A.REBMC Card 09: Burnup Dependent MCNP Input Lines for Cell Portion of Deck

It may be appropriate for some models to have a set of burnup dependent cell cards for the MCNP input decks edited by the REBUS-MCNP interface. For instance, a control rod model might apply different surfaces for control rod cells at different cycle times in order to model rod motion.

Read as:

```
09 TIMMIN TIMMAX TIMFLG CellCard
```

Read with free format.

Where:

TIMMIN: Minimum cycle time, in days, at which the card should be edited.
Entry is required, there is no default or overlay.

TIMMAX: Maximum cycle time, in days, at which the card should be edited.
Entry is required, there is no default or overlay.

TIMFLG: Integer flag for how to treat repeated time steps (e.g., power change, rod motion, or fuel shuffling modeled as two steps at the same time: before the change and after the change)
0 to edit the card any time the time range is satisfied
1 to edit the card ONLY the first time the time range is satisfied
2 to edit the card ONLY the second time the time range is satisfied

CellCard: MCNP Input Card text to be edited when TIMMIN≤cycle time≤TIMMAX
(up to 255 characters, to accommodate a comment for the MCNP line)
One blank character is expected after the TIMFLG entry, after which all remaining characters will be edited in the first column of the MCNP input deck.

Data Entry Requirements:

Up to 500 cards of type 09 may be read.

All cards appropriate for the cycle time of the REBUS depletion will be edited in the order they appear in the A.REBMC deck.

All cards edited will be written after all other MCNP template cell cards, or following a comment card in that template with key word REBREP. That is, if a comment containing REBREP exists in the cell input of the MCNPINPA template, then no cell cards that follow that comment in the template will be copied, but any appropriate A.REBMC Card Type 09 data will be edited after that point in the MCNP file produced.

Example:

```
09 0.0 1.0 0 C Control Rod
09 0.0 1.0 0 98 18 -7.8 ( -61 60 -66:                $ SS clad
09 0.0 1.0 0            66 -67 (-50 51: -56 57):
09 0.0 1.0 0            67 -65 64 ) 68 -69 u=4
09 0.0 1.0 0 99 19 -8.65 ( -60 59 -66:               $ Cd
09 0.0 1.0 0            66 -67 (-51 52: -55 56):
09 0.0 1.0 0            67 -64 63 ) 68 -69 u=4
09 0.0 1.0 0 100 18 -7.8 ( -59 58 -66:               $ SS clad
09 0.0 1.0 0            66 -67 (-52 53: -54 55):
09 0.0 1.0 0            67 62 -63) 68 -69 u=4

09 1.1 7.0 1 C Control Rod
09 1.1 7.0 1 98 18 -7.8 ( -61 60 -66:                $ SS clad
09 1.1 7.0 1            66 -67 (-50 51: -56 57):
09 1.1 7.0 1            67 -65 64 ) 78 -69 u=4
09 1.1 7.0 1 99 19 -8.65 ( -60 59 -66:               $ Cd
09 1.1 7.0 1            66 -67 (-51 52: -55 56):
09 1.1 7.0 1            67 -64 63 ) 78 -69 u=4
09 1.1 7.0 1 100 18 -7.8 ( -59 58 -66:               $ SS clad
09 1.1 7.0 1            66 -67 (-52 53: -54 55):
09 1.1 7.0 1           67 62 -63) 78 -69 u=4

09 1.1 7.0 2 C Control Rod
09 1.1 7.0 2 98 18 -7.8 ( -61 60 -66:                $ SS clad
09 1.1 7.0 2            66 -67 (-50 51: -56 57):
09 1.1 7.0 2            67 -65 64 ) 88 -69 u=4
09 1.1 7.0 2 99 19 -8.65 ( -60 59 -66:               $ Cd
09 1.1 7.0 1            66 -67 (-51 52: -55 56):
```

```
09 1.1 7.0 1            67 -64 63 ) 88 -69 u=4
09 1.1 7.0 1 100 18 -7.8 ( -59 58 -66:                $ SS clad
09 1.1 7.0 1             66 -67 (-52 53: -54 55):
09 1.1 7.0 1           67 62 -63) 88 -69 u=4
```

In this example, the cell definitions edited would be:

1. cells that apply boundary surface 68 would be applied for any time steps with cycle time ≤1.0 day, whether the first or second evaluation at the time step
2. cells that apply boundary surface 78 would be applied for time steps with 1.1≤time ≤7.0 days, for the first evaluation at the time step (i.e., before any change other than time step)
3. cells that apply boundary surface 88 would be applied for time steps with 1.1≤time ≤7.0 days, for the second evaluation at the time step (i.e., after any change other than time step)
4. none for cycle time>7.0 days

Note that this approach requires 9 cell cards per time step due to their complex construction. Other approaches as described by cards 10 and 11 will generally be more efficient.

Note, too, that overlap of time ranges is neither checked nor excluded.

A.REBMC Card 10: Burnup Dependent MCNP Input Lines for Surface Portion of Deck

It may be appropriate for some models to have a set of burnup dependent surface cards for the MCNP input decks edited by the REBUS-MCNP interface. For instance, a control rod model might apply different surface definitions at different cycle times in order to model rod motion.

Read as:

```
10 TIMMIN TIMMAX TIMFLG SurfCard
```

Read with free format.

Where:

TIMMIN: Minimum cycle time, in days, at which the card should be edited.
Entry is required, there is no default or overlay.

TIMMAX: Maximum cycle time, in days, at which the card should be edited.
Entry is required, there is no default or overlay.

TIMFLG: Integer flag for how to treat repeated time steps (e.g., power change, rod motion, or fuel shuffling modeled as two steps at the same time: before the change and after the change)
0 to edit the card any time the time range is satisfied
1 to edit the card ONLY the first time the time range is satisfied
2 to edit the card ONLY the second time the time range is satisfied

SurfCard: MCNP Input Card text to be edited when TIMMIN≤cycle time≤TIMMAX
(up to 255 characters, to accommodate a comment for the MCNP line)
One blank character is expected after the TIMFLG entry, after which all remaining characters will be edited in the first column of the MCNP input deck.

Data Entry Requirements:

Up to 500 cards of type 10 may be read.

All cards appropriate for the cycle time of the REBUS depletion will be edited in the order they appear in the A.REBMC deck.

All cards edited will be written after all other MCNP template surface cards, or following a comment card in that template with key word REBREP. That is, if a comment containing REBREP exists in the surface input of the MCNPINPA template, then no surface cards that follow that comment in the template will be copied, but any appropriate A.REBMC Card Type 10 data will be edited after that point in the MCNP file produced.

Example:

```
10  0.0 200.0 0 C Control Rod Lower Boundary
10  0.0   1.0 0 68 pz -27.65   $BOL Critical
10  1.1   7.0 0 68 pz -15.42   $Crit pos ave during Xe build in
10  7.1 200.0 0 68 pz  14.58   $Crit ave btw Xe build in and ARO
```

In this example, the surface definition edited for surface 68 would be:

1. pz -27.65 would be applied for time steps with cycle time ≤1.0 day
2. pz -15.42 would be applied for time steps with 1.1≤time ≤7.0 days
3. pz 14.58 for 7.1≤time ≤200.0 days

Note that this approach requires 1 surface card per time step due to the simple construction. More efficient than the approach described by card 09 example, but the translation approach exemplified for card type 11 is generally considered easier to track by other users.

Note, too, that overlap of time ranges is neither checked nor excluded.

A.REBMC Card 11: Burnup Dependent MCNP Input Lines for Data Portion of Deck

It may be appropriate for some models to have a set of burnup dependent data cards for the MCNP input decks edited by the REBUS-MCNP interface. For instance, a control rod model might apply different translation definitions at different cycle times in order to model rod motion.

Read as:

```
11 TIMMIN TIMMAX TIMFLG DataCard
```

Read with free format.

Where:

TIMMIN: Minimum cycle time, in days, at which the card should be edited.
Entry is required, there is no default or overlay.

TIMMAX: Maximum cycle time, in days, at which the card should be edited.
Entry is required, there is no default or overlay.

TIMFLG: Integer flag for how to treat repeated time steps (e.g., power change, rod motion, or fuel shuffling modeled as two steps at the same time: before the change and after the change)
0 to edit the card any time the time range is satisfied
1 to edit the card ONLY the first time the time range is satisfied
2 to edit the card ONLY the second time the time range is satisfied

DataCard: MCNP Input Card text to be edited when TIMMIN≤cycle time≤TIMMAX
(up to 255 characters, to accommodate a comment for the MCNP line)
One blank character is expected after the TIMFLG entry, after which all remaining characters will be edited in the first column of the MCNP input deck.

Data Entry Requirements:

Up to 500 cards of type 11 may be read.

All cards appropriate for the cycle time of the REBUS depletion will be edited in the order they appear in the A.REBMC deck.

All cards edited will be written after all other MCNP template surface cards, or following a comment card in that template with key word REBREP. That is, if a comment containing REBREP exists in the data input of the MCNPINPA template, then no data cards that follow that comment in the template will be copied, but any appropriate A.REBMC Card Type 11 data will be edited after that point in the MCNP file produced.

Example:

```
11  0.0 200.0 0 C Control Rod Lower Boundary
11  0.0   1.0 0 tr68 0 0 -27.65  $BOL Critical
11  1.1   7.0 1 tr68 0 0 -15.42  $Crit pos ave during Xe buildin
11  7.0   7.0 2 tr68 0 0  14.58  $Crit ave btw Xe build in & ARO
11  7.1 200.0 0 tr68 0 0  14.58  $Crit ave btw Xe build in & ARO
```

In this example, the data definition edited for translation 68 would be:

1. tr68 0 0 -27.65 would be applied for time steps with cycle time ≤1.0 day
2. tr68 0 0 -15.42 would be applied for time steps with 1.1≤time ≤7.0 days
   (including the first time step at 7.0 days, but not the second step after rods move)
3. tr68 0 0 14.58 for the second step at 7.0 days, then all steps with 7.1≤time ≤200.0 days

Note that this approach requires 1 translation card per time step due to the simple construction. More efficient than the approach described by cards 09 example, and generally considered easier to track by other users.than the burnup dependent surface definition approach exemplified for card type 10.

Note, too, that overlap of time ranges is neither checked nor excluded.

A.REBMC Card 12: Step Selection for One-Way Interface MCNP Deck Updates

The one-way interface where DIF3D is used for neutronic evaluation will update MCNP Input Decks at every time step unless one or more Cards of Type 12 exist to specify a subset of steps at which the MCNP Input Decks should be created. If one or mores Cards of Type 12 exist, then MCNP Input Decks will only be edited at the specified time steps.

Read as:

```
11 TIMMIN TIMMAX TIMFLG
```

Read with free format.

Where:

TIMMIN: Minimum cycle time, in days, at which an MCNP input deck should be edited. Entry is required, there is no default or overlay.

TIMMAX: Maximum cycle time, in days, at which an MCNP input deck should be edited. Entry is required, there is no default or overlay.

TIMFLG: Integer flag for how to treat repeated time steps (e.g., power change, rod motion, or fuel shuffling modeled as two steps at the same time: before the change and after the change)
0 to edit the deck any time the time range is satisfied
1 to edit the deck ONLY the first time the time range is satisfied
2 to edit the deck ONLY the second time the time range is satisfied

Data Entry Requirements:

Up to 500 cards of type 12 may be read.

Example:

Consider a REBUS-DIF3D model of two or more cycles of one year each:

```
12    0.0     0.0  0      $ Write an MCNP deck at BOL
```

```
12  364.99  365.01 0      $ Write an MCNP Deck at EOC1 and BOC2
12  729.99  730.01 1      $ Write an EOC2 MCNP Deck
```

In this example, an MCNP Input deck would be written only at:

1. cycle time = 0.0 day (only time test of equality can be trusted due to round-off)
2. time steps at 365 days (364.99≤time ≤365.01 days)
   (including both the EOC1 and BOC2 at same time, even though fuel was shuffled)
3. first time step evaluated at 730 days (i.e., would not edit EOC3 at same time)

Note that overlap of time ranges is neither checked nor excluded.

Recall that default is an edit at every time step if no Cards of Type 12 are in A.REBMC.

A.REBMC Card 13: Command to Invoke MCNP

REBUS uses a SYSTEM call to invoke MCNP so that the user's reference MCNP installation will be applied.

Read as:

```
13 'MCNPCALL'
```

Read with free format (so quotes are required if MCNPCALL includes spaces).

Where:

MCNPCALL: Character string of up to 256 characters that describes the exact command line syntax by which REBUS should call MCNP.
Entry is required, there is no default or overlay.

Data Entry Requirements:

One and only one card type 13 must be read.

Examples:

```
13  'mcnp tasks -20x1'
```

or

```
13  'runmcnp4clnx scriptargs'
```

Script Requirements:

Because a system call is used to invoke MCNP at each time step, MCNPCALL must not point to a script that expects interaction or a script that explicitly places execution in the background.

Verifying REBUS-MCNP Depletion for the Two-Way Interface

The REBUS Output File

- grep "K-EFF " on the output file (FT06 unless moved by a script) to build a table of the depletion results. Check the power level of each depletion step.
- Search for “ERROR:” (note colon) associated with the REBUS MCNP interface.
- Review the Interface input interpretations by searching for “REBUS-MCNP”. In particular, check the
    - MCNP System call by searching for “MCNP will be called by REBUS as”
    - “Summary of Material Applications in MCNP Input”
    - “Summary of Isotope Reactions Tracked in MCNP”

REBUS->MCNP Transfer trreb2mc_1

A distinct REBUS->MCNP transfer output file is created for each depletion step (e.g., trreb2mc_out_1, trreb2mc_out_2, etc.)

Search for “Summary of Material to Region Cross Reference”

- Verify the mass of U235 in each depleting region. Note that the volume of each region is from A.REBMC, while the number density of U235 is from the REBUS Input.
- Verify the “Total Volume Processed” and “Total Mass of U235”
- Verify that the correct lumped fission product has been assigned to each depleting region.

MCNP Input file inp_1

File inp_*n* is created for each depletion step *n* (e.g., inp_1, inp_2, etc.)

- Verify the number densities in the depleting regions in inp_1. The active isotopes are copied from REBUS Input to inp_1. The inactive isotopes do not exist in the abstract REBUS model, so they are copied from the A.REBMC Card Type 04.

- Verify the "Total Number of Material Definitions Updated" and the "Total Number of Cells Updated"

MCNP Output file outp

A distinct MCNP output file is created for each depletion step (e.g., outp_1, outp_2, etc.)

Verify the MCNP run by checking for any warnings or errors.

Note that MCNP is known to "hang" without error messages if there are problems with the cross section files. Verify the cross sections applied, particularly the fission products and actinides.

MCNP -> REBUS Transfer trmc2reb_1

A distinct MCNP -> REBUS transfer output file is created for each depletion step (e.g., trmc2reb_out_1, trmc2reb_out_2, etc.)

Search for "Summary of Tally Relative Errors Read"

- Verify the sigmas are reasonable for reaction rates used to determine one group cross sections. The captures in actinides are good indicators. The RERTR team checks that capture reaction rates have variances of:
    - U235 Capture sigma < 1%
    - U238 Capture sigma < 2%
    - Pu240 Capture sigma < 2%
    - U234 Capture sigma < 5%
    - U236 Capture sigma < 5%
    - Pu242 Capture sigma < 5%

  The trmc2reb files summarize RMS, minimum, and maximum sigmas among all depleting materials for each reaction tallied of each isotope.

REBUS-MCNP Restart Capability

A restart capability exists to allow a REBUS-MCNP two-way interface job that is interrupted or must be continued to avoid repetition of MCNP calculations.

No changes to input need to be made in order to restart (or continue) a REBUS-MCNP job. The user must simply copy the MCNP Tally Files for all completed steps to the run directory (generally accomplished via the script used to submit a REBUS-MCNP job).

The REBUS path driver checks for the existence of the MCNP Tally file associated with the current depletion point before calling MCNP (i.e., mctal_1 for BOL, mctal_2 for the second point, mctal_3 for the third, etc.). If the file exists, then MCNP will be skipped at that point and the existing tally file will be used.

Note that there is no way for REBUS to verify that the tally file is or is not correct for the current job. The user must take care to make sure that tally files copied for restart are appropriate for the current run (i.e., same time step size and power level leading up to each step copied, in addition to the same BOL model in both REBUS and MCNP).

buildreb Utility Program

The auxiliary program buildreb automates the repetitive tasks required to create an abstract REBUS model to complement an existing MCNP model.

Output files from buildreb:

- Complete REBUS input file (name set by A.BLDREB Card Type 03, default REBDECK)
  buildreb will create cards:
  - A.NIP3 Cards of Type 06
  - A.NIP3 Cards of Type 07
  - A.NIP3 Cards of Type 09
  - A.NIP3 Cards of Type 13, 14 & 15
  - A.BURN Cards of Type 10
  - A.BURN Cards of Type 35

- Complete a.rebmc
  buildreb will create the A.REBMC Cards of Type 01
  (name set by A.BLDREB Card Type 04, default a.rebmc.out)

- MCNP Template for use by REBUS-MCNP
  buildreb will update cell cards and/or material definitions, if desired
  (name set by A.BLDREB Card Type 02, default MCNPTMPL)

- Optional complete one group ISOTXS file,
  i.e., each active isotope for each depleting region
  (name set by A.BLDREB Card Type 05, default isoone.out)

Input files for buildreb:

- Required A.BLDREB read from standard input

- MCNP Template file(s) (names set by A.BLDREB card type 02)
  At least one MCNP input file is required
  - MCNPINP: Optional file from which to read active isotope umber densities
  - MCNPFRSH: Optional file from which to read fresh fuel number densities (which allows a burnup edit to be produced)
  - MCNPREPL: Optional file to act as basic template for output MCNP template (where cell definitions and/or material assignments may be altered by buildreb)

- Optional invariant portions of REBUS Input Deck (e.g., memory, burn matrix definition, etc.)
  (names set by A.BLDREB card type 03)
  - ANIP3HEAD: cards that precede A.NIP3 Cards of Type 06 created by buildreb
  - ABURNHEAD: cards that follow A.NIP3 Cards created by buildreb but precede A.BURN cards created by buildreb

- Required partial a.rebmc (i.e., all cards except A.REBMC Card Type 01)
  (name set by A.BLDREB Card Type 04, default a.rebmc)

- Optional partial one group ISOTXS file, i.e., each active isotope for one depleting region
  (name set by A.BLDREB Card Type 05, no default)

Running buildreb:

Buildreb.exe can be called as a simple executable, as in:

```
buildreb.exe < a.bldreb >! buildreb.out
```

As shown, the A.BLDREB input is read from standard input. The buildreb process output is written to standard output. All other input and output files are specified in A.BLDREB.

Table 7: buildreb Input Cards

Card	Issue for REBUS-MCNP Interface	Required?
01	**Naming Schemes**	**Required**
02	**MCNP Files** Note that MCNPINP is typical and allows model error checking	**Optional, but typical**
03	**REBUS Files** ANIP3HEAD and ABURNHEAD enable best automation	**Optional, but typical**
04	A.REBMC Files	Optional
05	**ISOTXS Files**	**Optional, but typical**
06	**Unique Isotope Prefixes**	**Optional, but typical**
07	**Fuel Group Specification**	**Required**
08	**Fuel Group Geometry**	**Required**
09	Fuel Group Naming Options	Optional
10	Fuel Group Number Densities	Optional
11	MCNP Deck Material Reassignment	Optional
12	MCNP Deck Cell Definition Override	Optional
13	MCNP Deck Material Definition Override	Optional

A.BLDREB Card Type 01: Naming Schemes

(Required)

The core job of buildreb is to create a correlated list of MCNP compositions and REBUS zones (geometric region and compositions) from minimal input.

A.BLDREB card type 01 specifies how names will be created.

Two concepts of the input are:

- Level: a grouping within the 3D geometry (e.g., axial zones within a larger 3D volume)
- Style: the manner in which numeric indices for levels are concatenated to create a unique identifier
- Loop Order: the order in which loops for the axial, radial, and/or set levels are nested as regions are created and edited. The looping order may be distinct from the style order in order to improve model readability.

Card 01 is read as:

```
01 REBSTYLE, ZMAX, [REBPAD], [MCNPSTYLE], [MCNPPAD], [ZONLOOPO], [ARESTYLE],
      [GEOSTYLE], [NSTAGES]
```

Read as free format tokens to avoid the need for quotes.

Where:

REBSTYLE: Required Character string to specify style of REBUS id increment on all cards
Up to five characters built of A, R, and S for axial, radial, set, respectively
or N for index count (where N is exclusive of A, R, S)

Repetition indicates number of digits in which to edit the associated integer index
e.g., AASSS would allow 100 axial planes (0-99) in 1000 sets (0-999)
ASS would allow 10 axial planes (0-9) in 100 sets (0-99)

Note that the starting indices (e.g., 0, 1, 21, etc.) are set on A.BLDREB Card 07
The indices can increase to the limit implied by the REBSTYLE

The "Set" level is generally useful for an assembly or reactor region.

ZMAX: Required Real number to specify the maximum axial height (cm) of the overall geometry modeled in the REBUS model. This is generally the active fuel height of the tallest fuel element.

REBPAD: Optional Character flag of 1 to 4 characters indicating whether the Axial, Radial, Set and iNdex levels should be padded or trimmed in REBUS id

Padding refers to leading 0s: the integer 1 becomes 01 if padded to length 2

The default is no padding. REBPAD must list any level that should be padded. e.g., AS would pad axial, not pad radial, would pad set, would not pad iNdex

If no padding should be applied, then the REBPAD field should be skipped by commas on the input line.

MCNPSTYLE: Optional Character string to specify style of MCNP material id incrementing Same input conventions as REBSTYLE, but may differ from the REBUS zone naming

For instance, an MCNP model may have radial subzone in model for non-REBUS use, but radial sub-zones might not be tracked in the associated REBUS model. In that case, REBSTYLE=ASS and MCNPSTYLE=ARSS

Default is MCNPSTYLE=REBSTYLE

If the default is acceptable, then the MCNPSTYLE field should be skipped by commas on the input line.

MCNPPAD: Optional Character flag of 1 to 4 characters indicating whether the Axial, Radial, Set and iNdex levels should be padded or trimmed in MCNP material id

Padding refers to leading 0s: the integer 1 becomes 01 if padded to length 2

The default is no padding. MCNPPAD must list any level that should be padded. e.g., AS would pad axial, not pad radial, would pad set, would not pad iNdex

If no padding should be applied, then the MCNPPAD field should be skipped by commas on the input line.

ZONLOOPO: Optional Character specification of looping order for buildreb edits
First unique character specifies the innermost loop
Second unique character specifies the middle loop
Third unique character specifies the outer loop

e.g., ARS specifies axial planes as inner loop, radial subzones as middle, set as outer
SA specifies set as inner loop, axial planes as outer loop

The order of zones edited does not effect the MCNP or REBUS models, but following a consistent convention will improve readability of the models.

Default is ZONLOOPO inferred from REBSTYLE (i.e., REBSTYLE copied, but repeated characters in REBSTYLE ignored)

If the default is acceptable, then the ZONLOOPO field should be skipped by commas on the input line.

ARESTYLE: Optional Character string of 1 or 2 characters to specify style of A.NIP3 Card 07 Areas
The entry specifies which variations within the ZONLOOPO nested loop (Axial, Radial, Set and/or iNdex levels) should be aggregated into an A.NIP3 Card Type 07 Area (for REBUS edits).

e.g., A to collect range of axial planes with same set and radial subzone as an area
AR to collect range of axial planes and radial subzones with same set as an area

See the extensive examples below.

Default is to aggregate inner most active loop of ZONLOOPO into areas.

If the default is acceptable, then the ARESTYLE field should be skipped by commas on the input line.

GEOSTYLE: Optional Character string of 1 or 2 characters to specify style of geometric zone increment on A.NIP3 Card 06
X to increment x extent of each zone, with consistent y and z extents
Y to increment y extent of each zone, with consistent x and z extents
Z to increment z extent of each zone, with consistent x and y extents
XZ to increment x extent of each set, z extent of each plane, consistent y
YZ to increment y extent of each set, z extent of each plane, consistent x

Default is X, the easiest scheme to read on A.NIP3 Card 06
The X boundaries applied should then just be radial area (i.e., XY) of the zone

If the default is acceptable, then the GEOSTYLE field should be skipped by commas on the input line.

NSTAGES: Optional Integer, number of stages used to represent distinct burnup step sizes
Used in edit of A.BURN Card 35.

Default is 1.
If the default is acceptable, then the NSTAGES field should be skipped by commas on the input line.

Examples:

```
01  ARSS,7.62,S, , ,SRA, , , , 4
Default prefixes applied
```

would be interpreted as:

- REBSTYLE: ARSS
- ZMAX: 7.62 cm (height of tallest single axial zone, NOT total height of problem)
- REBPAD: S (set level will be edited as 01, 02, …)
- MCNPSTYLE: Skipped, so default, i.e., match REBSTYLE
- MCNPPAD: Skipped, so default, i.e., match REBPAD
- ZONLOOPO: SRA
- ARESTYLE: Skipped, so default, i.e., group innermost loop of ZONLOOPO, A
- GEOSTYLE: Skipped, so default Y
- NSTAGES: 4

Because MCNP material numbering will not contain leading 0s, it is generally “neat” (i.e., less confusion between levels of planes or assemblies)

MCNP model: 2 assemblies, each with 3 axial planes and 2 radial sub-zones

REBUS model with 4 stages (due to changes in burn step size or power level)

```
A.BLDREB Card:      01  ARSS,7.54, S, , ,SRA, , , 4
```

Loop Region within buildreb	Axial Zone	Radial SubZone	Fuel Asm (Set)	REBUS Region A.NIP3 Card 6 (Prefix N)	MCNP Material (Prefix m)	REBUS Area A.NIP3 Cad 7 (Prefix FA)
1	1	1	1	N1101	m1101	FA101
2	2	1	1	N2101	m2101	
3	3	1	1	N3101	m3101	
4	4	1	1	N4101	m4101	
5	5	1	1	N5101	m5101	
6	1	2	1	N1201	m1201	FA201
7	2	2	1	N2201	m2201	
8	3	2	1	N3201	m3201	
9	4	2	1	N4201	m4201	
10	5	2	1	N5201	m5201	
11	1	1	2	N1102	m1102	FA102
12	2	1	2	N2102	m2102	
13	3	1	2	N3102	m3102	
14	4	1	2	N4102	m4102	
15	5	1	2	N5102	m5102	
16	1	2	2	N1202	m1202	FA202
17	2	2	2	N2202	m2202	
18	3	2	2	N3202	m3202	
19	4	2	2	N4202	m4202	
20	5	2	2	N5202	m5202	

ARESTYLE Examples based on REBSTYLE=ARSS, PREFARE=FA, PREFZON=N (where PREFARE and PREFZON are prefixes set on A.BLDREB Card Type 09)

ARESTYLE=A to collect range of axial planes with same set and radial subzone as an area, as in A.NIP3 Card Type 07s:

```
07  FA101  N1101 N2101 N3101
07  FA201  N1201 N2201 N3201
07  FA102  N1102 N2102 N3102
07  FA202  N1202 N2202 N3202
```

ARESTYLE=AR to collect range of axial planes and radial subzones with same set as an area, as in A.NIP3 Card Type 07s:

```
07  FA01  N1101 N2101 N3101  N1201 N2201 N3201
07  FA02  N1102 N2102 N3102  N1202 N2202 N3202
```

ARESTYLE=AS to collect range of axial planes and sets with same radial subzone as an area, as in A.NIP3 Card Type 07s:

```
07   FA1  N1101 N2101 N3101  N1102 N2102 N3102
07   FA2  N1201 N2201 N3201  N1202 N2202 N3202
```

ARESTYLE=R to collect range of radial subzones with same set and axial plane as an area, as in A.NIP3 Card Type 07s:

```
07  FA101  N1101 N1201
07  FA201  N2101 N2201
07  FA301  N3101 N3201
07  FA102  N1102 N1202
07  FA202  N2102 N2202
07  FA302  N3102 N3202
```

ARESTYLE=RS to collect range of radial subzones and sets with same axial plane as an area, as in A.NIP3 Card Type 07s:

```
07  FA1  N1101 N1201 N1102 N1202
07  FA2  N2101 N2201 N2102 N2202
07  FA3  N3101 N3201 N3102 N3202
```

ARESTYLE=S to collect range of sets with same axial planes and radial subzone as an area, as in A.NIP3 Card Type 07s:

```
07  FA11  N1101 N1102
07  FA21  N2101 N2102
07  FA31  N3101 N3102
07  FA12 N1201 N1202
07  FA22 N2201 N2202
07  FA32 N3201 N3202
```

Note that the order of characters in ARESTYLE does not affect the edit Areas will be defined and filled in the order dictated by zone order (per REBSTYLE)

A.BLDREB Card Type 02: MCNP Files

(Optional)

Card 02 is read as:

```
02 [MCNPINP], [MCNPFRSH], [MCNPREPL], [MCNPTMPL]
```

Read as free format, but quotes are required on each field (to support file paths).
If the paths must span multiple lines, then the continuation line(s) must begin with 2 or more spaces.

Where:

MCNPINP: Optional File name from which to read MCNP material descriptors in order to read number densities for REBUS A.NIP3 Card Type 13

If MCNPINP is skipped, then each zone group should have A.BLDREB card 10, and the MCNPINP field should be skipped by input of ‘ ‘ on the input line.

MCNPFRSH: Optional File name from which to read fresh fuel MCNP material descriptors in order to read number density of U-235

If MCNPFRSH is skipped, then no burnup edits will be edited, and the MCNPFRSH field should be skipped by commas on the input line.

MCNPREPL: Optional File name from which to read all input except specific cell definition cards, which will be replaced by the MCNPINP data

If MCNPREPL is skipped, then MCNPINP is copied rather than MCNPREPL, and the MCNPREPL field should be skipped by input of ‘ ‘ on the input line.

MCNPTMPL: Optional File name of MCNP template OUTPUT by buildreb
Default is MCNPTMPL, but the program will abort if the file already exists.
If the default is acceptable, then the MCNPTMPL field should be skipped by

input of ‘ ‘ on the input line.

MCNPTMPL will not be edited if MCNPINP is not entered.

Example:

```
02  'mcnpinpa' 'MCNPFRSH'/
```

Note the slash to end free format read since MCNPREPL and MCNPTMPL are not specified.

*** MAJOR CAVEAT REGARDING MCNP INPUT FILE MERGE OPERATIONS ***

The only input lines modified if an MCNPREPL deck is specified are:

- The first line of a cell definition that contains a depleting material and/or is in material application shuffle list
- The material definitions for depleting materials

Any cell properties on subsequent lines of the MCNPREPL input WILL NOT be modified by the operation

Fortunately, this behavior can also be exploited to advantage, as in the case of an MCNPINP deck and MCNPREPL deck that represent different cycles or reactivity coefficient calculations.

Consider an MCNPINP deck with the correct depleted number densities, but incorrect geometry (such as Be block placement or an additional assembly) and/or distinct cell properties such as temperature for a Doppler reactivity calculation.

The MCNPREPL deck could be correct in every respect except number densities.

The MCNPTMPL Output would then have all the structure of the MCNPREPL deck, but with cell material and density replaced as directed by A.BLDREB Card 12 NUMREPL directives, and material definitions replaced, per A.BLDREB Card 12 NUMMATL directives.

A.BLDREB Card Type 03: REBUS Files

(Optional)

Card 03 is read as:

```
03 [ANIP3HEAD], [ABURNHEAD], [REBDECK]
```

Read as free format, but quotes are required on each field (to support file paths).
If the paths must span multiple lines, then the continuation line(s) must begin with 2 or more spaces.

Where:

ANIP3HEAD: Optional File name from which to read header which precedes A.NIP3 cards in output REBUS deck. For instance, A.STP027, etc., which are not edited by buildreb.

If ANIP3HEAD is skipped, then no header will be copied, and the ANIP3HEAD field should be skipped by input of ‘ ‘ on the input line.

ABURNHEAD: Optional File name from which to read header which precedes A.BURN cards in output REBUS deck. For instance, cards 03, 36, 09, etc., that are not edited by buildreb.

If ABURNHEAD is skipped, then no header will be copied, and the ABURNHEAD field should be skipped by input of ‘ ‘ on the input line.

REBDECK: Optional File name of REBUS input deck OUTPUT by buildreb
Default is REBDECK, but the program will abort if the file already exists.
If the default is acceptable, then the REBDECK field should be skipped by input of ‘ ‘ on the input line.

Example:

```
03  'ANIP3HEAD'  'ABURNHEAD'/
```

Note the slash to end free format read since REBDECK is not specified.

A.BLDREB Card Type 04: A.REBMC Files

(Optional if default names are acceptable)

Card 04 is read as:

```
04 [AREBMCIN], [AREBMCOUT]
```

Read as free format, but quotes are required on each field (to support file paths).
If the paths must span multiple lines, then the continuation line(s) must begin with 2 or more spaces.

Where:

AREBMCIN: Optional File name of A.REBMC deck read for input (card type 01s ignored, others read)

Default is a.rebmc
If the default is acceptable, then the AREBMCIN field should be skipped by input of ‘ ‘ on the input line.

AREBMCOUT: Optional File name of A.REBMC input deck created by buildreb

Default is a.rebmc.out, but the program will abort if the file already exists.
If the default is acceptable, then the AREBMCOUT field should be skipped by input of ‘ ‘ on the input line.

A.REBMC Card Type 01s are created by buildreb, other cards are copied from AREBMCIN

Example:

```
04  'a.rebmc.for_buildreb'/
```

Note the slash to end free format read since AREBMCOUT is not specified.

A.BLDREB Card Type 05: ISOTXS Files

(Optional)

Card 05 is read as:

```
05 [ISOONEIN], [ISOONEOUT]
```

Read as free format, but quotes are required on each field (to support file paths).
If the paths must span multiple lines, then the continuation line(s) must begin with 2 or more spaces.

Where:

ISOONEIN: Optional File name of one-group ISOTXS file from which to read structure, energy/fission, and energy/capture

If ISOONEIN is skipped or A.BLDREB Card 04 is omitted, then no ISOTXS processing will be performed

ISOONEOUT: Optional File name of ISOTXS input deck created by buildreb

Default is isoone.out

Example:

```
05  'REBdummy.ISOTXS' 'REBdummy.ISOTXS_6ax'/
```

Note the slash to end free format read is not needed in this case, but is a good habit.

If ISOONEIN is specified, then ISOTXS processing will be performed. The one-group structure will be edited as necessary (i.e., expanded or contracted) so that the resulting file has a record set for each depleting isotope in each region.

REBUS MCNP does not use the cross-sections, but does need the structure to be correct so that the MCNP reaction rate tally cross sections can be transmitted to REBUS depletion by the interface.

A.BLDREB Card Type 06: Unique Isotope Prefixes

(Optional, but typical)

Card Type 06 specifies the correspondence between the "unique isotope identifier" prefixes used in ISOTXS and the REBISO equivalent "local isotope name" (per A.REBMC Card Type 05 for A.BURN Card 10). For instance, unique identifiers for the regions LPFH0, LPFH1, etc. might correspond to REBISO LumpFP.

Card 06 is read as:

```
06 ISOUNQP REBISO
```

Read as free format tokens to avoid the need for quotes.

Where:

ISOUNQP: 3 Character prefix for the unique isotope identifier

REBISO: 1-6 Character Local Isotope Label associated with ISOUNQP
(no quotes; must match an A.REBMC Card Type 05 REBISO entry)

If the overall list is incomplete (i.e., an A.BLDREB Card Type 06 is not entered for one or more REBISO), then ISOUNQ(i) is set equal to the first 3 characters pf REBISO(i) for each isotope not explicitly set by an A.BLDREB Card Type 06.

Example:

```
C
C ISOUNQP  REBISO
06 I35     I135
06 X35     XE135
06 P49     PM149
06 S49     SM149
06 U34     U234
06 U35     U235
```

A.BLDREB Card Type 07: Fuel Group Specification

(Required)

The concept of multiple fuel groups allows:

a) assemblies of different volumes, INTFMAT, and/or initial compositions to be modeled

b) distinct WIMS isotope sets for more than 100 compositions,

where prefix must change ISOA0 -ISOA99, ISOB0 -ISOB99

(counters can automatically roll over from ISOA99, ISOB0, ISOB1, etc., but user may desire discontiguous sets)

(automatic rollover is by sequence: ABCDEFGHIJKLMNOPQRSTUVWXYZ0123456789)

For each fuel group, Cards of Type 07 and 08 are required; and optional cards of type 09, and 10 may also be entered.

Card 07 is read as:

```
07 REGGRP, INSET, [ISETSTR], INAXL, [IAXLSTR], INRAD, [IRADSTR], [IISOSTR],
      [NSETSTR]
```

Read as free format tokens to avoid the need for quotes.

Where:

REGGRP: Required Character region group name of 1-6 characters used to cross-reference A.BLDREB Cards of Type 07, 08, 09, and 10

INSET: Required Integer Number of set members within group (typically the number of assemblies)

ISETSTR: Optional Integer Number at which to start counter for set, i.e., S index within REBSTYLE

Default is ISETSTR=-1, which implies keep counting S as in prior group.
If the default is acceptable, then the ISETSTR field should be skipped by commas on the input line.

INAXL: Required Integer Number of axial planes within group, i.e., A index within REBSTYLE

IAXLSTR: Optional Integer Number at which to start counter for axial planes, i.e., A index within REBSTYLE

Default is IAXLSTR=-1 implies just keep counting A as in prior group.
If the default is acceptable, then the IAXLSTR field should be skipped by commas on the input line.

INRAD: Required Integer Number of radial sub-zones within group, i.e., R index within REBSTYLE

IRADSTR: Optional Integer Number at which to start counter for radial subzones, i.e., R index within REBSTYLE

Default is IRADSTR=-1 implies just keep counting R as in prior group.
If the default is acceptable, then the IRADSTR field should be skipped by commas on the input line.

IISOSTR: Optional Integer Number at which to start counter for isotope index for set

Default is IISOSTR=-1 implies just keep counting ISO as in prior group.
If the default is acceptable, then the IISOSTR field should be skipped by commas on the input line.

NSETSTR: Optional Integer Number at which to start counter for index edit (REBSTYLE N) (i.e., an offset for edit of zone edit)

Default is NSETSTR=-1 implies just keep counting N as in prior group.
If the default is acceptable, then the NSETSTR field should be skipped by commas on the input line.

Data Entry Requirements:

Note that some non-zero combination of INSET, INAXL, and INRAD must always be entered to loop through zone edits, even if REBSTYLE N suppresses their explicit edit. The number of zones edited for the group is NZONE= INSET*INAXL*INRAD.

Example:

```
07 Stndrd  22, 1, 6,  0,  1,  1,  0
```

Defines a REGGRP named “Stndrd” with 22 members (assemblies in this case, as is typical).

Numbering of set members will begin with ISETSTR=1

Each of the 22 members of the set will have INAXL= 6 axial planes and INRAD=1 radial subzones.

Number of planes, radial subzones, and the REBISO unique isotope set applied will each begin with at 0 (i.e., plane 1 will have index 0, U235 would be U35A0 due to Card Type 06 example).

A.BLDREB Card Type 08: Fuel Group Geometry

(Required)

Card 08 is read as:

```
08 REGGRP, XYAREA, INTFMAT , [IZLOW], [IZEXT], [YINCR]
```

Read as free format tokens to avoid the need for quotes.

Where:

REGGRP: Required Character region group name of 1-6 characters used to cross-reference A.BLDREB Cards of Type 07, 08, 09, and 10

XYAREA: Required Real Number Area of fuel meat in xy plane (cm^2) applied to each zone in group.

INTFMAT: Required Interface Material name (1-6 characters) matching an A.REBMC Card Type 02 which specifies which active and inactive isotopes will be applied for the material

IZLOW: Optional Integer Number of lower Z mesh boundary within set for A.NIP3 Card Type 06
Default 0
If the default is acceptable, then the IZLOW field should be skipped by commas on the input line.

IZEXT: Optional Integer Number of Z extent of each zone within se set for A.NIP3 Card Type 06

for GEOSTYLE=X or Y, IZEXT is fixed, IZHI= IZLO+IZEXT

for GEOSTYLE=Z, XZ, or YZ, IZHI increments with IZEXT as scale
e.g., for IZLO=0 and IZEXT=2,
Five axial planes would vary as 0-2, 2-4, 4-6, 6-8, 8-10

Default 1

If the default is acceptable, then the IZEXT field should be skipped by commas on the input line.

YINCR: Optional Real Number Increment to apply to Y axis extent (cm) of each zone

Default 1.0

If the default is acceptable, then the YINCR field should be skipped by commas on the input line.

The IZLO=0, IZEXT=1 default combination implies that each region has the full height of ZMAX (which is set on A.BLDREB Card Type 01), if no REGGRP set has IZEXT>1.

The A.NIP3 Card Type 09 mesh boundaries are created by finding all X, Y, and Z boundaries of the regions created by buildreb.

Example:

```
08 Stndrd   5.9699   ACTVFU   0   1   1.0
```

Defines a REGGRP named “Stndrd” with:

- XYAREA= 5.9699 cm^2
- Interface material ACTVFU (which must match A.REBMC Card Type 02)
- 1 axial plane per set member, from 0 to 1 on Z mesh
- Y increment of 1.0, consistent with GEOSTYLE=’X’ per A.BLDREB Card Type 01 example

A.BLDREB Card Type 09: Fuel Group Naming Options

(Optional)

Card 09 is read as:

```
09 REGGRP, [CHISO], [PREFZON], [PREFARE], [PREFMAT], [PREFCMP], [PREFREG]
      [PREFPTH], [PREFMCNP]
```

Read as free format tokens to avoid the need for quotes.

Where:

REGGRP: Required Character region group name of 1-6 characters used to cross-reference A.BLDREB Cards of Type 07, 08, 09, and 10

CHISO: Optional Single character for iso group (such as A-Z, or 0-9),

Default (i.e., skipped field) just keeps counting per prior group.
If the default is acceptable, then the CHISO field should be skipped by commas on the input line.

WIMS will only increment from 0-99, so for problems with more than 100 regions the increment is preceded by a letter A-Z or 0-9, thus allowing up to 3600 regions.

PREFZON: Optional Single character prefix for REBUS zones (A.NIP3 Card 06)
Default N.
If the default is acceptable, then the PREFZON field should be skipped by commas on the input line.

PREFARE: Optional One or Two character prefix for area (A.NIP3 Card 07)
Default N.
If the default is acceptable, then the PREFARE field should be skipped by commas on the input line.

PREFMAT: Optional Single character prefix for materials (A.NIP3 Card 13)
Default M.
If the default is acceptable, then the PREFMAT field should be skipped by commas on the input line.

PREFCMP: Optional Single character prefix for primary compositions (A.NIP3 Card 14)
Default S.
If the default is acceptable, then the PREFCMP field should be skipped by commas on the input line.

PREFREG: Optional Single character prefix for regions (A.NIP3 Card 15)
Default R.
If the default is acceptable, then the PREFREG field should be skipped by commas on the input line.

PREFPTH: Optional Single character prefix for paths (A.BURN Card 35)
Default P.
If the default is acceptable, then the PREFPTH field should be skipped by commas on the input line.

PREFMCNP: Optional Single character prefix for MCNP material cards (either m or M)
Default m.
If the default is acceptable, then the PREFMCNP field should be skipped by commas on the input line.

Example:

```
09 Stndrd A N N  M S R P m
```

Note that no quotes are needed since card is read as a list of tokens.

A.BLDREB Card Type 10: Fuel Group Number Densities

(Optional)

Card Type 10 allows entry of the number densities of active isotopes for use on REBUS A.NIP3 Cards of Type 13 and for edit to MCNPTMPL.

Use of MCNPINP of A.BLDREB Card Type 02 is generally easier since the MCNPINP will include inactive isotopes, whereas the abstract REBUS model does not include inactive isotopes.

Card 10 is read as:

```
10 REGGRP ISOEQUIV(1) RNUMDN(1) [ISOEQUIV(2) RNUMDN(2) … ISOEQUIV(3) RNUMDN(3)]
```

Read as free format tokens to avoid the need for quotes.

Where:

REGGRP: Required Character region group name of 1-6 characters used to cross-reference A.BLDREB Cards of Type 07, 08, 09, and 10

For each non-zero isotope i from 1 to the number of active isotopes associated with INTFMAT (where INTFMAT applied to REGGRP is specified on A.BLDREB Card 08):

ISOEQUIV(i): 1-6 Character local isotope identifier for isotope (per A.BURN Card 10) (no quotes; must match an A.REBMC Card Type 05 REBISO entry)

RNUMDN(i): Number density of the isotope (atoms/b-cm)

Up to 3 ISOEQUIV/RNUMDN pairs may be entered on each card 10.

If the list is incomplete (i.e., not all active isotopes of the INTFMAT are input), then other isotopes are not edited for the MCNP deck, and edited with 1.0E-21 in the REBUS deck.

Example:

```
10  Stndrd  U235 3.85E-03    U238 2.79E-04
```

Note that no quotes are needed since card is read as a list of tokens.

A.BLDREB Card Type 11: MCNP Deck Material Reassignment (Optional)

One card each for the material applications to be shuffled by reassignment relative to the MCNPINP file

Card 11 is read as:

```
11 MATWAS MATNOW
```

Read as free format tokens.

Where:

MATWAS: Integer id of the material assigned to cells of the MCNPREPL input file
For instance, MCNP material m1101 has integer id 1101

MATNOW: Integer id of the material assigned to the same cells upon write of the cell definition to the MCNPTMPL output file
For instance, MCNP material m1106 has integer id 1106

Example:

Shuffling for the MCNP deck is performed by changing which material is assigned to the cells.

For instance, a card 11 that stated:

```
11  1101 1106
```

Would cause cell definition 10304 of the MCNPREPL file:

```
10304 like 10104 but u=301 MAT=1101 RHO=5.57656E-02  imp:n=1
```

to be written to MCNPTMPL as:

```
10304 like 10104 but u=301 MAT=1106 RHO=5.24195E-02  imp:n=1
```

A.BLDREB Card Type 12: MCNP Deck Cell Definition Override

(Optional)

One card each for cell definition that should be copied from MCNPINP input file to the MCNPTMPL output file, rather than from MCNPREPL.

Card 12 is read as:

```
12 NCELLREP
```

Read as free format tokens.

Where:

NCELLREP: Integer id of the cell definition card to be copied from the MCNPINP input file to the MCNPTMPL output file, rather than from MCNPREPL

If NCELLREP=0, then every definition of a cell containing a depleting material will copied from MCNPINP rather than the MCNPREPL.

Example:

For instance, a card 12 that stated:

```
12  10104
```

Would cause cell definition of the MCNPINP file:

```
10104  1101 5.114086E-02 152 -153 -502 503 -379 353 u=101
```

to be written to standard output in place of MCNPREPL file line:

```
10104  1106 5.24195E-02  152 -153 -502 503 -379 354 u=101
```

Any cell which is not present on an A.BLDREB Card Type 12 will be copied from MCNPREPL to MCNPTMPL, unless a Card Type 12 sets NCELLREP 0.

If MCNPINP is not specified on A.BLDREB Card Type 02, then no cards of type 12 should be in input.

If MCNPINP is specified on A.BLDREB Card Type 02, but MCNPREPL is not specified on A.BLDREB Card Type 02, then cards of type 12 will be ignored since all cell definitions will be copied from MCNPINP to MCNPTMPL.

A.BLDREB Card Type 13: MCNP Deck Material Definition Override

(Optional)

One card each for material definition that should be copied from MCNPINP input file to the MCNPTMPL output file, rather than from MCNPREPL.

Card 13 is read as:

```
13 NMATREP
```

Read as free format tokens.

Where:

NMATREP: Integer id of the material definition card to be copied from MCNPINP input file to the MCNPTMPL output file, rather than from MCNPREPL.

If NMATREP=0, then every definition of a depleting material will copied from MCNPINP rather than the MCNPREPL.

Example:

For instance, a card 13 that stated:

```
13  1101
```

Would cause material definition of the MCNPINP file:

```
m1101   61148.62c 5.22206E-10  61148.61c 2.28166E-10  61147.61c 1.87128E-07
        61147.62c 2.11017E-07  53135.61c 1.17343E-08  54135.61c 1.10432E-08
        61149.61c 1.63612E-08  62149.61c 1.19237E-07  92234.60c 1.80075E-05
        92235.60c 2.40754E-03  92236.60c 2.54733E-05  92238.60c 9.70293E-03
        94238.60c 4.25068E-11  94239.60c 1.87254E-06  94240.60c 6.44471E-09
        94241.60c 5.42674E-11  94242.60c 7.43556E-14  95241.60c 6.78075E-14
        93237.60c 2.00507E-08
        999907.69d 1.80126E-05   8017.60c 1.22161E-06
        13027.60c 3.06388E-02 14000.60c 8.32642E-03
```

to be written to standard output in place of MCNPREPL file lines:

```
m1101   61148.62c 8.19455E-09  61148.61c 1.63116E-10  61147.61c 1.17042E-06
        61147.62c 1.31983E-06  53135.61c 1.41182E-19  54135.61c 2.03558E-19
        61149.61c 3.56971E-11  62149.61c 1.79022E-07  92235.60c 1.87199E-03
        92236.60c 2.39954E-05  92238.60c 1.45082E-04  94238.60c 7.66166E-10
```

```
94239.60c 5.70490E-07  94240.60c 1.53389E-08  94241.60c 8.46808E-10
94242.60c 1.03028E-11  95241.60c 9.21379E-12  93237.60c 6.86519E-08
999927.69d 1.26689E-04   8017.60c 9.82325E-06
13027.60c 5.38114E-02
```

Any material which is not present on an A.BLDREB Card Type 13 will be copied from MCNPREPL to MCNPTMPL, unless a Card Type 13 sets NMATREP 0.

If MCNPINP is not specified on A.BLDREB Card Type 02, then no cards of type 13 should be in input.

If MCNPINP is specified on A.BLDREB Card Type 02, but MCNPREPL is not specified on A.BLDREB Card Type 02, then cards of type 13 will be ignored since all cell definitions will be copied from MCNPINP to MCNPTMPL.

WIMS-ANL Use for Lumped Fission Product and ISOTXS Template

69 Group Lumped Fission Product

- Run ***wimslnxexe*** in 69 groups
  - e.g., NGROUP 69 7 7
  - ISOXS card must specify ISM0=1 so that MCNPXS file will be written
  - EDITCELLS must specify only fuel meat
  - ISONAMES and ISOTOPES cards must be consistent, and should save only those isotopes that deplete in the REBUS-MCNP model.
  - Save burnup steps via IBURN card to capture shape of the lumped fission product vs. U235 burnup, where closest match will be applied (i.e., no interpolation of lumped fission product cross sections is applied by MCNP, just closest match)
  - Save the 69 Group **MCNPXS** file when wimslnxexe is run
  - Save the associated **ISOTXS** in order to extract the U235 number density from record 4D of each step saved (used for A.REBMC card type 06)

- Run ***wims2mclnxexe*** to convert input MCNPXS to an MCNP library (for xsdir application)
  - iso label '9999' or some other non-physical ZAID
  - MAT ID ' mt9999'
    where leading spaces are important (4 indicated here)
    9999 must match the iso label
  - Apply resulting library steps in the xsdir, as in:

```
…. Atomic weight ratio portion of xsdir …
999901  120.000000  999902  120.000000  999903  120.000000  999904  120.000000
…. Directory portion of xsdir ….
999901.69d 120.000 rpi06l /data/EP/jgslfp/rpi06l 1    1 474 0 0 2.530E-08
999902.69d 120.000 rpi06l /data/EP/jgslfp/rpi06l 1  132 474 0 0 2.530E-08
999903.69d 120.000 rpi06l /data/EP/jgslfp/rpi06l 1  263 474 0 0 2.530E-08
999904.69d 120.000 rpi06l /data/EP/jgslfp/rpi06l 1  394 474 0 0 2.530E-08
```

where 999901.69d is the first burnup step saved, 999902.69d the second burnup step saved, etc.

- Apply the discrete ZAID via a drxs card in the MCNP input

- Extract U235 number density of each burnup step from ISOTXS to create A.REBMC Cards of Type 06
  - Convert binary ISOTXS to ASCII AISO via ***cvisoexe***, using 6 digits for AISO
  - Extract the U235 number density of each step via
    extract_U35_from_AISO_for_MCREBUS.csh < AISO
    where standard output of script will contain relevant data

1 Group ISOTXS Template

- Run ***wimslnxexe*** in 1 groups
  - e.g., NGROUP 69 1 1
    VECTOR 69
  - EDITCELLS must specify only fuel meat
  - ISONAMES and ISOTOPES cards must be consistent
  - ISONAMES must define a set of names consistent with ISOUNQP of A.BLDREB Cards of Type 06

- Save one burnup steps via IBURN card to save a unique isotope set for each burn region , such as U235H0

- buildreb can be used to copy the single saved step to as many regions as necessary.

Example of wims2lnxexe Execution Script Use at ANL

```
sol15: 74 => wims2mclnxexe
/home/sol1/johnstevens

*****  Generation of MCNP XS from WIMS data *****

Is a special module required? (y|n -n default):  n

Enter fully qualified MCNPXS input file name:  /home/sol1/johnstevens/RPI/WIMS/RPI-heu-
18plate/69group_isotxs_ok/MCNPXS

Standard output files include /home/sol1/johnstevens/RPI/WIMS/RPI-heu-
18plate/69group_isotxs_ok/MCNPXS xslib1 xsdir1 specs atomwts
Do you wish to save files other than standard output? (y|n -n default):  n

Choose short term storage device number (shortn - specify n):  1

Execute from the following directory:
/var/tmp/johnstevens/wims2mcnp6275

Library information (e.g. '/shorti/bnnnnn/wims2mcnp1234/outlib' and the
simple file name 'outlib') must be provided at the following prompts,
note the length limitations:

 Enter FULLY qualified SPECS library file name IN QUOTES, max. 29:

'library_loc_path/libnam'

 Enter SIMPLE SPECS library name, OMITTING directory, max. 6:
'libnam'

 Enter 4 digit integer for isotope label or 0 for default:
9999

 Enter atomic weight or 0 for default:
0

 Enter temperature, MeV or 0 for default:
0

 Enter 10 character date, e.g. 04/19/2001, IN QUOTES:
'01/10/2007'

 Enter library identifier IN QUOTES, max. 70:

'Example of wims2mclnxexe execution'

 Enter MAT identifier IN QUOTES with left fill, max. 10:
'    mt9999'

 >>> If you would like to continue with a custom selection of input enter a CR
 or if you would like to take the defaults for Lumped Fission Product Data enter  1:
1

 Enter number of WIMS burn steps:
35
Isotope:  999901
Isotope:  999902
Isotope:  999903
Isotope:  999904
Isotope:  999905
Isotope:  999906
Isotope:  999907
Isotope:  999908
Isotope:  999909
Isotope:  999910
Isotope:  999911
Isotope:  999912
```

```
Isotope:  999913
Isotope:  999914
Isotope:  999915
Isotope:  999916
Isotope:  999917
Isotope:  999918
Isotope:  999919
Isotope:  999920
Isotope:  999921
Isotope:  999922
Isotope:  999923
Isotope:  999924
Isotope:  999925
Isotope:  999926
Isotope:  999927
Isotope:  999928
Isotope:  999929
Isotope:  999930
Isotope:  999931
Isotope:  999932
Isotope:  999933
Isotope:  999934
Isotope:  999935

MCNP Discrete Reaction Data Library - XSLIB created
```

Resulting ASCII files

```
sol15: 83 => cat specs
xsdir1 xsdir2
libnam   2
library_loc_path/libnam
 999901.69d 999902.69d 999903.69d 999904.69d 999905.69d 999906.69d 999907.69d
 999908.69d 999909.69d 999910.69d 999911.69d 999912.69d 999913.69d 999914.69d
 999915.69d 999916.69d 999917.69d 999918.69d 999919.69d 999920.69d 999921.69d
 999922.69d 999923.69d 999924.69d 999925.69d 999926.69d 999927.69d 999928.69d
 999929.69d 999930.69d 999931.69d 999932.69d 999933.69d 999934.69d 999935.69d
```

Note the libnam and library_loc_path/libnam entered for script input above

```
sol15: 84 => cat atomwts
999901  120.000000  999902  120.000000  999903  120.000000  999904  120.000000
999905  120.000000  999906  120.000000  999907  120.000000  999908  120.000000
999909  120.000000  999910  120.000000  999911  120.000000  999912  120.000000
999913  120.000000  999914  120.000000  999915  120.000000  999916  120.000000
999917  120.000000  999918  120.000000  999919  120.000000  999920  120.000000
999921  120.000000  999922  120.000000  999923  120.000000  999924  120.000000
999925  120.000000  999926  120.000000  999927  120.000000  999928  120.000000
999929  120.000000  999930  120.000000  999931  120.000000  999932  120.000000
999933  120.000000  999934  120.000000  999935  120.000000
```

Note default mass of 120 for lumped fission product is per higher yield peak

```
sol15: 85 => cat xsdir1
directory
999901.69d 120.000 xslib1 xslib1 1    1 474 0 0 2.530E-08
999902.69d 120.000 xslib1 xslib1 1  132 474 0 0 2.530E-08
999903.69d 120.000 xslib1 xslib1 1  263 474 0 0 2.530E-08
999904.69d 120.000 xslib1 xslib1 1  394 474 0 0 2.530E-08
999905.69d 120.000 xslib1 xslib1 1  525 474 0 0 2.530E-08
999906.69d 120.000 xslib1 xslib1 1  656 474 0 0 2.530E-08
999907.69d 120.000 xslib1 xslib1 1  787 474 0 0 2.530E-08
999908.69d 120.000 xslib1 xslib1 1  918 474 0 0 2.530E-08
999909.69d 120.000 xslib1 xslib1 1 1049 474 0 0 2.530E-08
999910.69d 120.000 xslib1 xslib1 1 1180 474 0 0 2.530E-08
```

```
999911.69d 120.000 xslib1 xslib1 1 1311 474 0 0 2.530E-08
999912.69d 120.000 xslib1 xslib1 1 1442 474 0 0 2.530E-08
999913.69d 120.000 xslib1 xslib1 1 1573 474 0 0 2.530E-08
999914.69d 120.000 xslib1 xslib1 1 1704 474 0 0 2.530E-08
999915.69d 120.000 xslib1 xslib1 1 1835 474 0 0 2.530E-08
999916.69d 120.000 xslib1 xslib1 1 1966 474 0 0 2.530E-08
999917.69d 120.000 xslib1 xslib1 1 2097 474 0 0 2.530E-08
999918.69d 120.000 xslib1 xslib1 1 2228 474 0 0 2.530E-08
999919.69d 120.000 xslib1 xslib1 1 2359 474 0 0 2.530E-08
999920.69d 120.000 xslib1 xslib1 1 2490 474 0 0 2.530E-08
999921.69d 120.000 xslib1 xslib1 1 2621 474 0 0 2.530E-08
999922.69d 120.000 xslib1 xslib1 1 2752 474 0 0 2.530E-08
999923.69d 120.000 xslib1 xslib1 1 2883 474 0 0 2.530E-08
999924.69d 120.000 xslib1 xslib1 1 3014 474 0 0 2.530E-08
999925.69d 120.000 xslib1 xslib1 1 3145 474 0 0 2.530E-08
999926.69d 120.000 xslib1 xslib1 1 3276 474 0 0 2.530E-08
999927.69d 120.000 xslib1 xslib1 1 3407 474 0 0 2.530E-08
999928.69d 120.000 xslib1 xslib1 1 3538 474 0 0 2.530E-08
999929.69d 120.000 xslib1 xslib1 1 3669 474 0 0 2.530E-08
999930.69d 120.000 xslib1 xslib1 1 3800 474 0 0 2.530E-08
999931.69d 120.000 xslib1 xslib1 1 3931 474 0 0 2.530E-08
999932.69d 120.000 xslib1 xslib1 1 4062 474 0 0 2.530E-08
999933.69d 120.000 xslib1 xslib1 1 4193 474 0 0 2.530E-08
999934.69d 120.000 xslib1 xslib1 1 4324 474 0 0 2.530E-08
999935.69d 120.000 xslib1 xslib1 1 4455 474 0 0 2.530E-08
```

Note default temperature is room temperature

To use the cards in xsdir1, name xslib1 will need to be edited to point to the final location of the xslib created by conversion of MCNPXS to xsli1b by wims2mclnxexe

```
sol15: 87 => cat xslib1 | more
999901.69d  120.000000  2.5300E-08 01/10/2007
Example of wims2mclnxexe execution                                          mt9999
      0         0.      0         0.      0         0.      0         0.
      0         0.      0         0.      0         0.      0         0.
      0         0.      0         0.      0         0.      0         0.
      0         0.      0         0.      0         0.      0         0.
      474   999901       70        2        1        0        0        0
        0        0        0        0        0        0        0        0
        1        0      351      353      355      357      359      461
      463      463      464        0        0        0        0        0
        0        0        0        0        0      474        0        0
        0        0        0        0        0        0        0        0
  9.999999960000E-12  4.999999970000E-09  9.999999940000E-09  1.499999950000E-08
  1.999999990000E-08  2.500000030000E-08  2.999999890000E-08  3.499999930000E-08
screen echo truncated
```

File xslib1 is the actual MCNP library for the lumped fission products

Example of rebmc07 Execution Script Use at ANL

```
sol16: 22 => rebmc07

************************************************************
**   REBUS-MCNP With System Call to User Specified MCNP   **
************************************************************

Current directory is : /home/sol1/johnstevens/MCREB/iaea06/inputs

REBUS Executable set to:
/home/sol1/johnstevens/MCREB_Code/rebusmc07/lf95/rebmcnpjgs_lf95_070216.exe


Do you wish to run:
0 the current version of the MCNP neutronics interface, with a.rebmc as single interface input
file, or
1 prior version of the MCNP neutronics interface, with postone.inp and posttwo.inp, or
2 DIF3D version of the interface (to update mcnpinpa with REBUS compositions)
Select 0, 1, or 2 [default is 0]:

   The input files must have the proper case and base name:
       a.rebmc, the MCNP<->REBUS Interface Input directives
       rebusinp, the REBUS Input
       mcnpinpa, the MCNP Input Template
       tasks, the PVM parallel processing directive
       isoone, the one-group ISOTXS file with a unique set of active isotopes for each REBUS
region

   A link should be established before running this script if your files have a more descriptive
name, as in:
   ln -s good_descriptive_name_of_REBUS_model.inp rebusinp


Enter fully qualified directory path to input files for the combined REBUS-MCNP model
(relative paths with . or .. are OK, default is . ):
Checking MCNP<->REBUS, a.rebmc :  ./a.rebmc
Checking REBUS input, rebusinp :  ./rebusinp
Checking MCNP input, mcnpinpa :  ./mcnpinpa
Checking PVM Tasks input, tasks :  ./tasks
Checking isoone :  ./isoone


Please review the PVM Task input:
--------------------------------
cat ./tasks
-12x1

Is the number of processes in the task file appropriate for the pvm environment?  (y|n     n is
default):y


Which MCNP cross section file, xsdir, would you like to apply:
  /data/RA/mcnp/xsdir does not exist
1  ~/xsdir
2  ./xsdir
  ./../xsdir does not exist
4 Other file to be specified
Select the number of the xsdir choice you would like to apply:   2

Which MCNP source file, srctp, would you like to apply:
0 for None
1  ./srctp
  ./../srctp does not exist
3 Other file to be specified
Select the number of the srctp choice you would like to apply:   1
```

```
Do you wish to perform a RESTART or CONTINUATION by bypassing MCNP execution for steps at which
tally files
   mctal_1, mctal_2, etc., already exist in .? (y|n     n is default):

Do you wish to bypass mcnpinpa->inp_1 creation by the REBMC07 interface at the initial step?
Please enter y or n? (y|n     n is default. It is very atypical to bypass):

Do you wish to input other files (RFILES)? (y|n     n is default):

*** Save files other than the normal output file in the standard
    directory? (y|n     n is default):
Short term storage device number 1 will be used

A REBUS-MCNP-PVM problem will now be submitted to the batch (b) queue.
 ************************************************************
  rebmc.log19341 will be the log file in your home directory.
  /short1/johnstevens/rebmc19341 is the output directory.
 ************************************************************

job 688 at 2007-02-22 00:04
sol16: 23 =>
```

Sample Problem: IAEA Generic 10 MW Reactor with LEU

An example problem is provided so that the distinct steps of a REBUS-MCNP depletion can be followed. The basic model is described in Reference 8.

Problem Setup Steps (sample problem directories have inputs and outputs)

1. Create WIMS-ANL Model
    - Save 69 group Lumped Fission Product vs. burnup for use in MCNP.
    - Convert MCNPXS to an MCNP xslib, and update xsdir to point to the lumped fission product libraries.
    - Save 1 group ISOTXS as basis for MCNP->REBUS cross-section transfer template.

2. Prepare qualified MCNP beginning of life model and prepare for depletion
    - Expand MCNP beginning of life model so that there is a distinct material for each depleting region. This generally requires splitting full height fuel meat cells into distinct axial sections. The material IDs should follow some naming scheme to facilitate model construction and verification.
    - Add a unique material for each active isotope so that reaction rates can be tallied.
    - Create tallies for one group fluxes in the fuel meat and one group reaction rates in the fuel meat.
    - Recall that buildreb can help edit MCNP input material definitions and assignment to cells for continuations of prior modeling. This does not apply to the IAEA sample problem.

3. Create a partial A.REBMC input file (all except Card Type 01)

4. Create an A.BLDREB file input file

5. Run buildreb to create abstract REBUS model, complete the A.REBMC, and proliferate the one group ISOTXS template to the number of unique isotopes.

6. Run REBUS-MCNP and verify proper execution

check_rebmc_model Utility Program

A simple utility program exists to check for consistency within and between an MCNP input file and an A.REBMC input file.

buildreb performs all of the same checks on the output files that are produced by a buildreb run.

REBUS also performs all of the same checks each time a run begins.

But, **use of the simple utility is highly suggested whenever a model is updated** since the model can be checked without the computational overhead of a REBUS run just to check for input consistency.

The executable expects two files in the run directory:

- a.rebmc, and
- mcnpinpa

Links can be used to point to more descriptive names.

There is no other input to check_rebmc_model.

A report of checks performed is written to standard output (including any warnings or errors detected)

check_rebmc_model.exe can be called as a simple executable, as in:

```
check_rebmc_model.exe >! check_rebmc_model.out
```

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Nuclear Engineering Division
Argonne National Laboratory
9700 South Cass Avenue, Bldg. 208
Argonne, IL 60439-4842

www.anl.gov

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